4.0 Numeric Targets

Pursuant to federal TMDL requirements, quantifiable and measurable numeric targets that will ensure compliance with water quality standards (beneficial uses and water quality objectives) must be established in the TMDL (US EPA, 1999). As discussed previously, municipal water supply (MUN), warm water aquatic habitat (WARM) and water contact and non-water contact recreation (REC1 and REC2) are the beneficial uses that are impaired by the high levels of nutrient inputs to Canyon Lake. For Lake Elsinore, warm freshwater aquatic habitat (WARM) and water contact and non-water contact recreation (REC1 and REC2) are the beneficial uses that are impaired by excessive nutrient input. The TMDL and its numeric targets must be structured to assure protection of all the beneficial uses and attainment of the nutrient- related water quality objectives specified in the Basin Plan.

To establish the numeric targets, Regional Board staff first considered use of established numeric nutrient objectives. As discussed in Section 2.5, the Basin Plan specifies numeric water quality objectives for nitrogen for both Lake Elsinore and Canyon Lake. The nitrogen objective for Lake Elsinore (TIN of 1.5 mg/L), was established in the 1975 Basin Plan based on the data then available. Since then, additional data have been collected. These data suggest that the TIN objective may not be protective of the beneficial uses. For Canyon Lake, the TIN objective of 8 mg/L was established to protect use of the lake for municipal supply. Again, this objective is not protective of the REC1, REC2 and WARM beneficial uses. The Basin Plan does not specify numeric water quality objectives for phosphorus for either lake. Revised nitrogen objectives and new phosphorus objectives for the lakes need to be developed and considered. If and when such objectives are incorporated in the Basin Plan, it would be appropriate to apply them in the selection of numeric targets. Development of these objectives is identified as a part of the Implementation Plan for this TMDL (see Section 9.0, Implementation Recommendations).

Until appropriate numeric objectives are established, alternative methods of identifying numeric targets must be used. Regional Board staff evaluated other alternatives to select both water quality indicators and target values. Using literature values is one approach. The US EPA National Eutrophication Survey of 894 US lakes and reservoirs resulted in classification of these lakes as oligotrophic, mesotrophic and eutrophic, based on water quality parameters such as total phosphorus, chlorophyll *a*, Secchi depth and hypolimnetic oxygen (US EPA, 1999). The values for either mesotrophic or eutrophic status have been used as long-term targets for other TMDLs (e.g., TMDL for Indian Creek Reservoir by the Lahontan Region, 2002). A second approach is to select a reference state of the water body when the beneficial uses were not impaired. Again, water quality parameters such as total phosphorus, chlorophyll *a*, secchi depth and hypolimnetic oxygen, as measured in this reference state condition, could serve as numeric targets. To define appropriate targets for protection of the REC1 and REC2 uses, data from a lake users survey could be used to link water quality parameters values to public perception of the suitability of the lake for these uses.

Board staff considered the literature values inappropriate for Lake Elsinore due to the fact that the lake has existed for over eight thousand years (Genda, 1993) and has a long eutrophic history (see Table 3-1 for fish kill record that dates back to 1933). Due to completely natural processes, Lake Elsinore has been at the eutrophic stage since the early 20th century, before the Clean

Water Act was enacted. Therefore, a reference state for Lake Elsinore based on historical water quality data seemed appropriate as the basis for selecting numeric targets. Using the same values for Canyon Lake provides consistency because the two lakes are nested in the same watershed, within five miles of each other.

4.1 Lake Elsinore Nutrient Numeric Targets

Numeric targets for phosphorus are proposed for Lake Elsinore. Phosphorus is critical, because under the present conditions, phosphorus is generally the limiting nutrient for algal growth in Lake Elsinore (Anderson, 2000). In addition, the literature review indicates that reducing phosphorus loading would: (1) reduce algal productivity; (2) reduce dissolved oxygen depletion during summer stratification, and thus reduce the associated risk of fish kills; (3) increase water clarity; and, (4) protect and enhance aquatic life and recreational uses. Staff also proposes nitrogen numeric targets due to the fact that nitrogen can be a limiting nutrient under certain hydrological conditions (Santa Ana RWQCB, October 2000) and because both the acute and chronic ammonia toxicity criteria have been exceeded in the past. Therefore, control of both phosphorus and nitrogen is needed to ensure the protection of the lake regardless of the limiting nutrient.

Indicators and targets for parameters other than phosphorus and nitrogen are also proposed in order to track Lake Elsinore's recovery from an eutrophic state. These targets include chlorophyll *a* and dissolved oxygen. Chlorophyll is an important target since it is the parameter most closely tied to public perception of water quality in the lake. Moreover, as a biological parameter, chlorophyll also serves as an important means to gauge biological response to nutrient loads. Dissolved oxygen also serves as a measure of Lake Elsinore's response to nutrient loads.

Proposed numeric targets for Lake Elsinore are shown in Table 4-1. Board staff proposes interim numeric targets and final numeric targets. Based on the expected efficacy of programs currently being implemented by LESJWA to improve Lake water quality, staff believes that the interim targets can be achieved by 2015. Additional investigation of the water quality measures needed to achieve the final numeric target is likely to be necessary, at least for Lake Elsinore. Thus a schedule of compliance no later than 2020 is proposed.

While the phosphorus and nitrogen numeric targets will be translated into specific load allocations, the chlorophyll *a* and dissolved oxygen numeric targets will be used to monitor the recovery of Lake Elsinore. If the total phosphorus and nitrogen targets are met while the other targets are not, or vice versa, the numeric targets will be re-evaluated and revised accordingly.

Derivation of the Lake Elsinore proposed targets and comparison of these targets to current water quality is discussed in detail below.

Table 4-1. Proposed Numeric Targets and Indicators for Lake Elsinore Nutrient TMDL

Indicator	Target Value[c]	Reference
Total P concentration (interim)[a]	Annual average no greater than 0.1 mg/L; to be attained no later than 2015	25th percentile of Lake Elsinore monitoring data (2000-2001considered as reference state of Lake Elsinore)
Total P concentration (final)[a]	Annual average no greater than 0.05 mg/L; to be attained no later than 2020	Model results discussed in Section 4.0
Total N concentration (interim)[a]	Annual average no greater than 1 mg/L; to be attained no later than 2015	A ratio of total N to total P of 10 is used to maintain the nutrient balance.
Total N concentration (final)[a]	Annual average no greater than 0.5 mg/L; to be attained no later than 2020	As above
Chlorophyll a concentration (interim)[b]	Summer average no greater than 40 µg/L; to be attained no later than 2015	25th percentile of Lake Elsinore monitoring data (2000-2001considered as reference state of Lake Elsinore)
Chlorophyll a concentration (final)[b]	Summer average no greater than 25 µg/L; to be attained no later than 2020	Eutrophic condition (USEPA, 1990, 1999)
Dissolved oxygen concentration (interim)[b]	Depth average no less than 5 mg/L; to be attained no later than 2015	Water quality objective in the Basin Plan
Dissolved oxygen concentration (final)[b]	No less than 5 mg/L 1 meter above lake bottom and no less than 2 mg/L from 1 meter to lake sediment; to be attained no later than 2020	Water quality objective in the Basin Plan

a. source targets related to load allocations/waste load allocations
b. monitoring targets that will not be used for load allocations/waste load allocations
c. compliance with the targets to be achieved as soon as possible, but no later than the date specified

4.1.1 Phosphorus and Nitrogen

Numeric Targets

The proposed interim target for total phosphorus is 0.1 mg/L as the annual average concentration in the water column. This number represents the 25th percentile of the total phosphorus concentration during the year 2000-2001 monitoring period. This time period is identified as the reference state since the lake did not experience severe algal blooms or fish kills, and the average lake elevation was 1240 feet above sea level, the acceptable operational level for Lake Elsinore. To maintain the balance of nutrients for beneficial algal growth, a ratio of total nitrogen to total phosphorus of 10 is used to derive the 1.0 mg/L interim target for total nitrogen (US EPA, 1990).

For the long-term total phosphorus target, staff initially considered a total phosphorus concentration of 0.02 mg/L, which is the concentration that US EPA considers as the dividing point between mesotrophic and eutrophic conditions. However, based upon further in-lake model evaluation, it appears that 0.02 mg/L would be unachievable in Lake Elsinore due to the excessive phosphorus load in the sediment and watershed inputs. Even if the internal phosphorus release rate is reduced by 70% and the external load is zero, the in-lake phosphorus concentration will never be less than 0.05 mg/L (see discussion in Section 6.0 and Figure 6-2). Therefore, Board staff proposes a long-term total phosphorus numeric target for Lake Elsinore of 0.05 mg/L. Again, using the 10:1 N to P ratio, the proposed long-term target for total nitrogen is a concentration no greater than 0.5 mg/L as an annual mean.

Comparison of Numeric Target and Existing Conditions in Lake Elsinore

Annual average total phosphorus and total nitrogen concentrations in Lake Elsinore from 1992 through 2002 are summarized in Table 4-2. Total phosphorus concentrations in Lake Elsinore have decreased since the wet conditions of 1993, while the total kjeldahl nitrogen[8] concentrations have not decreased as much. The decreasing trend in phosphorus concentrations suggests that the precipitation of phosphorus to the sediment has resulted in the removal of phosphorus from the water column. On the other hand, when the lake elevation decreases, as it has done from 2000 through 2002, the phosphorus sediment re-suspension rate and the internal flux of phosphorus increase, resulting in an increase of the total phosphorus concentration in the water column.

Table 4-2. Lake Elsinore total phosphorus and total kjeldahl nitrogen (TKN) concentrations (1992-2002)

Year	Annual Average Lake Elevation (feet asl)	Annual Average Total P (µg/L)	Annual Average TKN (mg/L)	Summer Average chlorophyll *a* (µg/L)	Data Source
1992*	1229	500	11.8	NA	SAWPA
1993	1254	678	3.24	126	SAWPA
1994	1253	371	NA	NA	SAWPA
1995	1255	260	2.89	99	SAWPA
1996	1252	213	3.05	88	SAWPA
1997	1247	195	3.08	NA	SAWPA
2000	1242	110	2.40	49	Regional Board
2001	1240	120	2.69	82	Regional Board
2002	1237	130	2.77	254	Regional Board

* Only one data point for the year
NA = no monitoring data available

[8] Total kjeldahl nitrogen (TKN), the sum of organic nitrogen and ammonium nitrogen, serves as a surrogate for total nitrogen in Lake Elsinore (note: in the TKN test both forms of ammonia – ammonium [ion] and unionized ammonia [gas] are converted to the ammonium form. It is the unionized ammonia form that is toxic to aquatic organisms. Analytical tests different from the TKN test are used to determine the concentration of the un-ionized form of ammonia). In Lake Elsinore, the major form of nitrogen exists in the organic form; nitrate and nitrite, the other inorganic forms of nitrogen, are typically below detection limits.

4.1.2. Dissolved Oxygen

Dissolved oxygen is a proposed water quality indicator for Lake Elsinore. Oxygen depletion has been the cause of fish kills in the lake. In addition, anoxic conditions promote release of phosphorus and ammonia from lake sediments. Benthic organisms may also be affected by anoxic conditions. Maintaining sufficient oxygen levels in the water column will prevent fish kills and reduce internal nutrient loading.

Numeric Target

The proposed dissolved oxygen interim target is a depth-averaged concentration of no less than 5 mg/L. This concentration assumes that the current fishery (mostly carp and shad) can survive under lower oxygen conditions as long as part of the lake is sufficiently oxygenated.

The final numeric target is equivalent to the narrative water quality objective for dissolved oxygen specified in the Basin Plan. The dissolved oxygen water quality objective is an instantaneous objective to be achieved at all times; however, the Basin Plan is not specific regarding applicability of the objective to the entire water column. For the final target, Board staff proposes that the 5 mg/L dissolved oxygen objective apply to the entire water column from 1 meter above the lake bottom. Selection of the 1 m depth is based on operational convenience because dissolved oxygen measurements are often taken at 1 m intervals in the water column. When the lake is stocked with fish such as trout, catfish and bass, which are less tolerant of low-oxygen conditions, the final target should be applied at all depths in order to protect all fish populations. To protect benthic organisms, dissolved oxygen concentrations of at least 2 mg/L from the lake bottom to 1 meter above the lake bottom is proposed as a target (CH2M Hill Technical Memo #3, 2003). It should be acknowledged that there have been no studies to demonstrate that dissolved oxygen concentrations of 2 mg/L will be protective of the benthic organisms. The number is based on best professional judgment at the present time. When future studies are conducted to establish the link between dissolved oxygen and the health of habitat in Lake Elsinore, the numeric target for dissolved oxygen will be reviewed and revised accordingly.

Comparison of Numeric Target and Existing Conditions

Depth profile monitoring by Regional Board staff and UC Riverside since 2000 shows that thermal stratification of Lake Elsinore is limited; stratification lasts only a few hours to several days. The water surface is generally saturated or over-saturated with oxygen due to the photosynthetic production of oxygen. Oxygen concentrations near the lake sediments tended to be lower, and on several sampling dates, approached zero. On numerous other dates, however, dissolved oxygen concentrations stayed above 1 mg/L, often approaching 5 mg/L (in 2000-2001). In the summer of 2002, very low dissolved oxygen concentrations were observed near the water/sediment interface. In July and August 2002, dissolved oxygen concentrations less than 5 mg/L throughout the water column occurred, resulting in a fish kill in late August (Anderson, 2002).

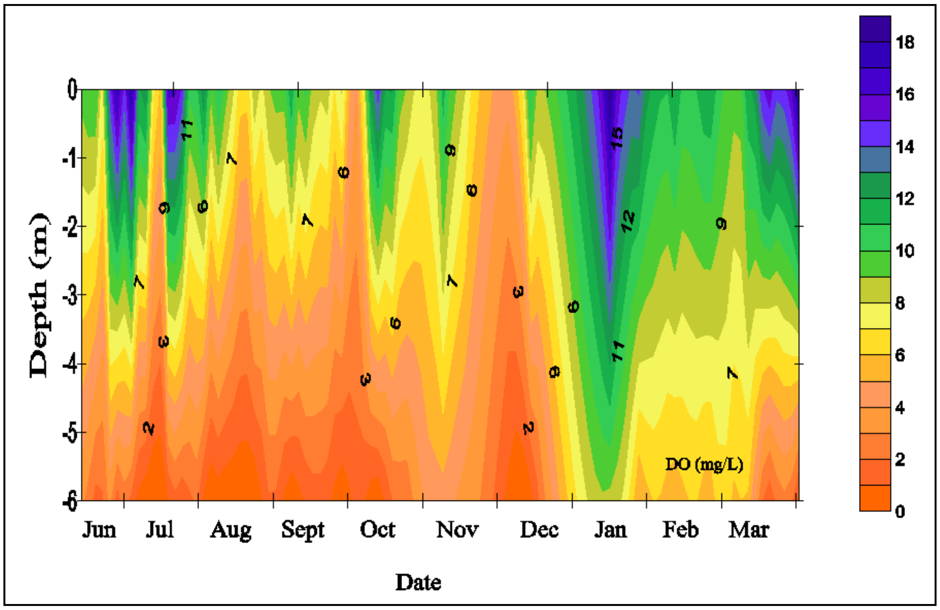


Figure 4-1. Lake Elsinore dissolved oxygen concentration from June 12, 2002 through March 26, 2003 (Anderson and Nascimento, 2003)

4.1.3. Chlorophyll *a*

Chlorophyll *a*, found in all algae and higher plants, is an indicator for algal biomass. It is also an important indicator of eutrophication status. In general, a lake with an average chlorophyll *a* concentration over 20 µg/L is considered eutrophic (US EPA, 2000).

Numeric Target

The proposed interim target for chlorophyll *a* is a summer average of 40 µg/L, which is the 25th percentile of the data collected during the 2000-2001 period, a reference state for Lake Elsinore. Coincidentally, the results of the Lake Users Survey of Lake Elsinore in April through September 2002 show that the majority of the users surveyed considered Lake Elsinore to be acceptable when chlorophyll *a* concentrations were 40 µg/L or less (Li, 2002).

For the long-term chlorophyll *a* target, the literature value of 25 µg /L is proposed. The US EPA national eutrophic survey data suggested that a chlorophyll *a* concentration of 10-25 ug/L corresponds to eutrophic conditions.

Comparison of Numeric Targets and Existing Conditions

Summer average chlorophyll *a* concentrations measured in the past 10 years are summarized in Table 4-2. The data clearly indicate the hypereutrophic state of Lake Elsinore. High summer average chlorophyll *a* concentrations are observed after the 1993 and 1995 floods, and in the middle of the drought of 2002. Flood waters likely carried high nutrient loads from the San Jacinto River watershed to Lake Elsinore, while the drought conditions of 2001 through 2002 caused the lake elevation to drop and the water temperature and phosphorus flux rate to increase.

Both conditions resulted in severe algal blooms, as evidenced by the elevated chlorophyll *a* concentrations.

4.2. Canyon Lake Nutrient Numeric Targets

Canyon Lake monitoring data collected by Regional Board staff and Elsinore Valley Municipal Water District (EVMWD) staff indicate that nitrogen is the primary limiting nutrient for Canyon Lake. However, both nitrogen and phosphorus can be the limiting nutrient for algal growth as the nutrient concentrations in Canyon Lake vary both spatially and temporally (Li, 2003). Therefore, both nutrients should be controlled in order to control excessive algal growth. Furthermore, since Canyon Lake overflows to Lake Elsinore in wet weather, it is necessary to also control the primary nutrient of concern in Lake Elsinore (phosphorus).

As with the Lake Elsinore proposed numeric targets, the Canyon Lake proposed numeric targets are also total phosphorus and total nitrogen. Other parameters, such as chlorophyll *a* and dissolved oxygen, are proposed as indicators for attainment of beneficial uses and to track the eutrophic status of Canyon Lake. The proposed indicators and targets are summarized in Table 4-3. Consistency with the proposed Lake Elsinore numeric targets serves as the primary criterion for selection of the numeric targets since no reference state can be identified for Canyon Lake due to lack of data.

Table 4-3. Numerical Targets and Indicators for Canyon Lake Nutrient TMDL

Indicator	**Target Value**[c]	**Reference**
Total P concentration (interim)[a]	Annual average no greater than 0.1 mg/L; to be attained by 2015	Consistent with Lake Elsinore
Total P concentration (final)[a]	Annual average no greater than 0.05 mg/L; to be attained by 2020	Consistent with Lake Elsinore
Total N concentration (interim)[a]	Annual average no greater than 1.0 mg/L; to be attained by 2015	Using a N:P ratio of 10:1
Total N concentration (final)[a]	Annual average no greater than 0.5 mg/L; to be attained by 2020	Using a N:P ratio of 10:1
Chlorophyll a concentration (interim)[b]	Annual average no greater than 40 µg/L; to be attained by 2015	Consistent with Lake Elsinore except using the annual average not the summer average (see text)
Chlorophyll a concentration (final)[b]	Annual average no greater than 25 µg/L; to be attained by 2020	Consistent with Lake Elsinore except using the annual average not the summer average (see text)
Dissolved oxygen concentration (interim)[b]	Minimum 5 mg/L above the thermocline and no less than 2 mg/L in hypolimnion; to be attained by 2015	Water quality objective in the Basin Plan
Dissolved oxygen concentration (final)[b]	Daily average at hypolimnion no less than 5 mg/L; to be attained by 2020	Water quality objective in the Basin Plan

a. source targets related to load allocations/waste load allocations;
b. monitoring targets that will not be used for load allocations/waste load allocations
c. compliance with the targets to be achieved as soon as possible, but no later than the date specified

4.2.1 Phosphorus and Nitrogen

Numeric Targets

To be consistent with the Lake Elsinore numeric targets, an annual average total phosphorus concentration no greater than 0.1 mg/L is proposed as an interim target for Canyon Lake. To maintain the 10:1 TP to TN ratio, an annual average total nitrogen no greater than 1.0 mg/L is proposed as an interim target. The final total phosphorus and total nitrogen proposed numeric targets are 0.05 mg/L and 0.5 mg/L, respectively.

Comparison of numeric targets and existing conditions

The annual average concentrations of total phosphorus and total nitrogen for Canyon Lake are summarized in Table 4-4. Both total phosphorus and total nitrogen concentrations are higher in Canyon Lake than in Lake Elsinore. One reason is that in most years, the flow from the San Jacinto River and Salt Creek watersheds containing nutrient loads drains to and remains in Canyon Lake. Canyon Lake also stratifies during the summer, with little or no oxygen in the hypolimnion; nutrients released from lake sediments are trapped and then released when the lake turns over in the fall.

Table 4-4.Canyon Lake Water Quality Data (1998-2002)

Year	Annual Average Lake Elevation (feet asl)	Total P (µg/L)	Total N (mg/L)	Chlorophyll a (µg/L)	Data Source
1998	1379	548	1.32	NA	EVMWD
1999	1377	208	1.63	NA	EVMWD
2000	1378	408	1.58	27	Regional Board
2001	1378	341	1.53	38	Regional Board
2002	1375	356	1.59	54	Regional Board

NA = data not available, no monitoring data collected

4.2.2 Chlorophyll *a*

Numeric Target

Chlorophyll *a* is selected as a secondary indicator because excessive algal growth as measured by chlorophyll *a* results in increased turbidity levels that, in turn, cause EVMWD to shut down its water treatment plant. The reduction in algal production will improve water clarity and turbidity. An interim chlorophyll *a* target of an annual average no greater than 40 ug/L is proposed. This target is consistent with the proposed chlorophyll *a* target for Lake Elsinore. However, for Canyon Lake an annual average of chlorophyll *a* is proposed (for Lake Elsinore a summer average is proposed). This is due to the fact that Canyon Lake chlorophyll *a* concentrations exhibit greater spatial and temporal variability than Lake Elsinore. The annual average is thus considered more representative of the eutrophic status. For the final goal, a numeric target of 25 ug/L of chlorophyll *a* is proposed. Again, this target is consistent with the long-term chlorophyll *a* target for Lake Elsinore, except that it is a summer rather than an annual average target for Lake Elsinore.

Comparison of Numeric Targets and Existing Conditions

The annual average chlorophyll *a* concentrations for Canyon Lake are summarized in Table 4-4. Overall, the chlorophyll *a* concentrations in Canyon Lake are much lower than chlorophyll *a* in Lake Elsinore, even though the nutrient concentrations in Canyon Lake are higher. Canyon Lake stratifies during the summer and the nutrients released from the lake sediment are trapped in the hypolimnion, and are not available for algal uptake. When the lake turns over in the fall, chlorophyll *a* levels rise and algal blooms generally occur. Algal blooms in Canyon Lake also occur in the spring due to inputs of nutrients from the watershed during the winter rainy season.

4.2.3 Dissolved Oxygen

Numeric Target

Control of dissolved oxygen is important for Canyon Lake since the depletion of oxygen has caused occasional fish kills, high nutrient flux rates from the sediment, and elevated concentrations of iron and manganese in the water that have posed difficulties for the water treatment plant. However, there are no data to determine the level of dissolved oxygen that would be protective of all beneficial uses. Once again, the existing Bain Plan objective and consistency with Lake Elsinore are the primary criteria in selecting the target value for dissolved oxygen. For the interim target, a minimum of 5 mg/L dissolved oxygen above the thermocline and no less than 2 mg/L dissolved oxygen in the hypolimnion is proposed. For the final target, a daily average dissolved oxygen concentration no less than 5 mg/L at the hypolimnion is proposed, which is equivalent to the dissolved oxygen water quality objectives specified in the Basin Plan. When additional studies are conducted to determine the appropriate dissolved oxygen level that is protective of all beneficial uses, the numeric target will be revised accordingly.

Comparison of Numeric Targets and Existing Conditions

As depicted in Figure 4-2, dissolved oxygen concentrations in Canyon Lake, measured from July 2001 through August 2002, are generally high at the surface but low in the thermocline and hypolimnion. Dissolved oxygen concentrations were less than 1 mg/L below approximately 5 meter depth (where the thermocline is present) almost 75% of the year (Anderson *et al.,* 2002).

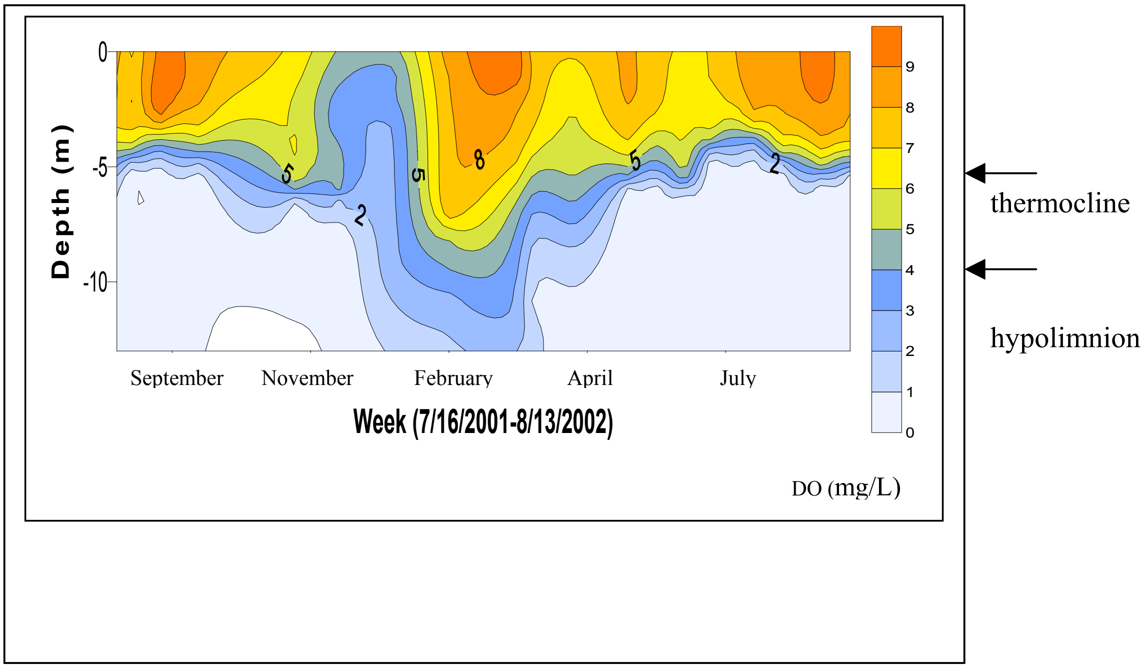


Figure 4-2. Canyon Lake dissolved oxygen profile (in mg/L) from July 2001 through August 2002 (from Anderson *et al*., 2002).

4.3. Ammonia Toxicity Criteria

Lake Elsinore ammonia concentrations have occasionally exceeded both the acute and chronic ammonia criteria developed by the US EPA (1999) (e.g., on 1/6/01 and 12/3/02, Regional Board and UCR data). The high ammonia concentrations were observed when the dissolved oxygen was low in the water column, indicating that ammonia could be a product of mineralization of organic matter. The combination of low dissolved oxygen concentrations and high ammonia can be detrimental to aquatic life in the lake (Anderson and Veiga Nascimento, 2003: 4th Quarterly Report for Lake Elsinore Recycled Water Project). Incorporating the ammonia criteria into the Lake Elsinore nutrient TMDL will help prevent ammonia toxicity to aquatic life that has been experienced in the lake in the past.

The ammonia criteria developed by US EPA (1999) are proposed as part of the long-term nitrogen target. These criteria are expressed as equations in which toxicity varies with pH and/or water temperature. These equations also vary based on whether or not salmonid fish species are present. Since there are no native salmonid fish present in Lake Elsinore, the acute toxicity target was calculated using the equation for when salmonid fish are absent. The chronic ammonia criteria were calculated using the equations for freshwaters when early fish life stages are present. The acute and chronic ammonia criteria equations and results are shown as follows:

1. 1-hour average concentration of total ammonia nitrogen (mg/L) does not exceed, more than once every three years on the average, the CMC (acute criteria)

$$CMC = 0.411/(1+10^{7.204-pH}) + 58.4/(1+10^{pH-7.204})$$

2. The thirty-day average concentration of total ammonia nitrogen (mg/L) does not exceed, more than once every three years on the average, the CCC (chronic criteria)

$$CCC = (0.0577/(1+10^{7.688-pH}) + 2.487/(1+10^{pH-7.688})) * \min(2.85, 1.45*10^{0.028(25-T)})$$

pH-dependent values of ammonia acute toxicity criteria (total ammonia nitrogen, in mg N/L)

pH	CMC
8.0	8.41
8.5	3.20
8.6	2.65
8.7	2.20
8.8	1.84
8.9	1.56
9.0	1.32
9.5	0.70
10.0	0.50

Temperature and pH-dependent values for ammonia chronic criteria (total ammonia nitrogen, in mg N/L)

	Temperature (C)								
	14	16	18	20	22	24	26	28	30
pH									
8.0	2.430	2.210	1.940	1.710	1.500	1.320	1.160	1.020	0.897
8.5	1.090	0.990	0.870	0.765	0.672	0.591	0.520	0.457	0.401
8.6	0.920	0.836	0.735	0.646	0.568	0.449	0.439	0.386	0.339
8.7	0.778	0.707	0.622	0.547	0.480	0.422	0.371	0.326	0.287
8.8	0.661	0.601	0.528	0.464	0.408	0.359	0.315	0.277	0.244
8.9	0.565	0.513	0.451	0.397	0.349	0.306	0.269	0.237	0.208
9.0	0.486	0.442	0.389	0.342	0.300	0.264	0.232	0.204	0.179

The ammonia criteria developed by US EPA (1999) are included as part of the long-term nitrogen targets for Canyon Lake as well. The equations and the results are the same as listed for Lake Elsinore. Examination of ammonia concentrations in Canyon Lake shows that ammonia concentrations in Canyon Lake are higher than in Lake Elsinore. But because the pH values are lower in Canyon Lake than in Lake Elsinore, the acute criteria for ammonia have not been exceeded during the monitoring period (2000-2002). However, the chronic criteria have been periodically exceeded (data not shown).

The ammonia criteria are proposed as part of the long-term numeric targets, rather than the interim targets, in light of the paucity of relevant data on both ammonia concentrations and their effects on the aquatic life in Lake Elsinore and Canyon Lake. Additional investigations of ammonia-related questions are proposed as part of the implementation plan for this TMDL.

5.0 Nutrient Source Assessment for Lake Elsinore and Canyon Lake

In order to determine the reductions needed to achieve the proposed nutrient numeric targets and, thereby, established water quality standards, and to allocate allowable nutrient inputs among the sources, it is necessary to consider the existing and potential nutrient sources, including point, non-point and background sources. In the language of federal regulations, individual Waste Load and Load Allocations for the different sources must be determined that together will result in compliance with the TMDL. In order to do this, it was necessary to characterize all nutrient sources in the San Jacinto watershed, both external and internal.

The source assessment is a component of the TMDL that evaluates the type, magnitude, timing, and location of loading to an impaired waterbody. Several factors should be considered in conducting the source assessment. These factors include identifying the various types of sources (e.g., point, nonpoint, background, atmospheric), the relative location and magnitude of loads from the sources, the transport mechanisms of concern (e.g., runoff, infiltration), and the time scale of loading to the waterbody (i.e., duration and frequency of nutrient discharge to receiving waters) (US EPA, 1999). All of these factors were evaluated as part of the Lake Elsinore/Canyon Lake nutrient TMDL source assessment.

Lake Elsinore and Canyon Lake receive runoff from the San Jacinto River, Salt Creek and local watersheds surrounding the lakes. The USGS multi-resolution land characteristics (MRLC) 1993 data were used to assess the land use characteristics of the San Jacinto River watershed. Land use in the watershed is predominantly shrubland and forest in the headwaters area and agriculture and urban in the middle and terminal areas of the watershed. Areas surrounding both lakes are highly developed.

The unique hydrology of the San Jacinto River largely controls the magnitude and distribution of nutrient loading from external sources. All the streams in the San Jacinto River watershed are ephemeral. External sources contribute nutrients to the lakes via storm flows during the wet season (October through April). However, under normal dry periods, the mainstem of the San Jacinto River is dry, contributing little or no flow to Canyon Lake, and upstream pollutants do not reach the lakes. Instead, pollutants accumulate on the land surface and are washed off during subsequent storm events. In significant rainfall conditions (with a frequency of approximately every 8 years), the main stem of the San Jacinto River overflows Mystic Lake to Canyon Lake, and Canyon Lake overflows to Lake Elsinore. When these significant rain events occur, there is frequently flooding in the basin, dairies are inundated, resulting in the transport of nutrient-rich manure and dairy wash water to the lakes. Since the lakes, particularly Lake Elsinore, are at the terminus of the watershed, the nutrient-laden flows accumulate in the lakes, causing internal nutrient loading to increase in subsequent years. In dry years, internal nutrient loading is the dominant source of nutrients to both Lake Elsinore and Canyon Lake (see the discussion in the following section).

Potential point source and nonpoint sources of nutrients to Canyon Lake and Lake Elsinore are summarized in Table 5-1.

Table 5-1. Lake Elsinore/Canyon Lake and San Jacinto River Watershed Potential Nutrient Source Inventory

Source	Applicable Permit (Principal Permittee and Permit No.)
Point Sources	
Urban Stormwater Runoff	➢ Waste Discharge Requirements (WDRs) for the Riverside County Flood Control and Water Conservation District and the Incorporated Cities of Riverside County within the Santa Ana Region, Areawide Urban Runoff, Order No. R8-2002-0011 (NPDES No. CAS 618033) ➢ WDRs for the United States Air Force, March Air Reserve Base, Storm Water Runoff, Riverside County, Order No. 99-6, NPDES No. CA 0111007 ➢ Order No. 99-06 – DWQ, NPDES No. CAS000003, NPDES Permit, Statewide Storm Water Permit and WDRs for the State of California, Department of Transportation (Caltrans)
Confined Animal Facility Operations (CAFO)	General Waste Discharge Requirements for Concentrated Animal Feeding Operations (Dairies and Related Facilities) Order No. 99-11 (NPDES No. CAG018001)
Tertiary Treated Wastewater and well water	Waste Discharge and Producer/User Reclamation Requirements for the Elsinore Valley Municipal Water District, Regional Water Reclamation Facility Riverside County Order No. R8-2002-0008-A02 (NPDES No. CA8000027)
Tertiary Treated Wastewater	Waste Discharge Requirements for Eastern Municipal Water District, Regional Water Reclamation System, Riverside County Order No. R8-2002-0008-A01 (NPDES No. CA8000188)
Stormwater Runoff associated with New Developments in the San Jacinto River Watershed	Watershed-Wide Waste Discharge Requirements for Discharges of Storm Water Runoff Associated with New Developments in the San Jacinto Watershed Order No. 01-34 (NPDES No. CAG 618005)
Nonpoint Sources	
Agricultural Land Runoff	None
Forest/Shrub-land/Open Space	None
Atmospheric Deposition	None
Internal Nutrient Source from Lake Sediment	None
Septic Systems	None
Other Livestock	None

Canyon Lake is designated as MUN (municipal and domestic supply) and, as described above, is used by EVMWD as a source for its customers. Given these circumstances, discharges of treated sewage to Canyon Lake or to any tributary to Canyon Lake are prohibited unless approved by the California Department of Health Services (1995 Basin Plan). Eastern Municipal Water District (EMWD) and Elsinore Valley Water District (EVMWD) are the two wastewater agencies serving the San Jacinto watershed. Currently, EMWD reclaims most of its wastewater for landscape and agricultural irrigation. EVMWD discharges most of its wastewater downstream of Lake Elsinore into Temescal Creek. EMWD also has a permit to discharge excess recycled water to Temescal Creek during periods when recycled water demands are low (typically the winter months).

Since Lake Elsinore is not designated MUN and is not used as a source of drinking water supply, the Basin Plan does not prohibit wastewater discharges to the Lake. In 2002, the Regional Board revised the NPDES permits for EVMWD and EMWD to allow for the discharge of limited volumes of tertiary-treated wastewater to Lake Elsinore. These revised permits authorize the implementation of a two-year pilot project. The permits will expire in December 2004., unless they are renewed. The purpose of this pilot project is to evaluate the feasibility and water quality effects of using recycled water to mitigate the evaporative water losses from Lake Elsinore. Maintenance of a stable lake level would enhance water quality and beneficial uses in the lake.

Additional point source discharges include those from urban stormwater outfalls that are currently regulated by an NPDES permit issued to the Riverside County Flood Control and Water Conservation District (RCFC&WCD) as Principal Permittee and the County of Riverside and the incorporated cities of Beaumont, Calimesa, Canyon Lake, Corona, Hemet, Lake Elsinore, Moreno Valley, Murrieta, Norco, Perris, Riverside, and San Jacinto as co-permittees. With the exception of the cities of Calimesa, Corona, and Norco, all other cities, or parts of the cities named above and part of the County of Riverside, drain into the San Jacinto River Watershed. Other major urban stormwater discharges include those from concentrated animal feeding operations (CAFOs) and March Air Reserve Base, which are regulated under NPDES permits adopted by the Regional Board in 1999, and those from state highways, which are regulated through the State Board's general Caltrans permit. None of these permits contain numerical effluent limits.

Nonpoint source (NPS) pollution also significantly affects the water quality of both Canyon Lake and Lake Elsinore. Unlike pollution from discrete points of discharge, NPS pollution comes from many diffuse sources that may be difficult to identify specifically. Major potential nonpoint source contributions of nutrients in the San Jacinto watershed include atmospheric deposition, agricultural runoff, and runoff from forest/shrub land/open space, septic systems and lake sediments.

The magnitude and variability of the nutrient loads from all of these nutrient sources were unknown when the TMDL effort started in 2000. Since then, limited studies have quantified the internal nutrient loads from sediments for Lake Elsinore and Canyon Lake (Anderson, 2001, Anderson and Oza, 2003). In addition, Regional Board staff, with funding assistance from LESJWA and the collaboration from stakeholders such as RCFC&WD, have been conducting a TMDL monitoring program in the watershed and in the lakes. The results from the monitoring program have assisted a model analysis to simulate the external nutrient loading from point and nonpoint sources to Lake Elsinore and Canyon Lake (Tetra Tech., Inc. 2003). The results from these studies are summarized and discussed below.

5.1 Internal Nutrient Loading in Lake Elsinore and Canyon Lake

In-lake sediments are a major source of nutrients that affect the water quality of Lake Elsinore and Canyon Lake. Nutrient-rich sediments are transported to the lakes from the San Jacinto River watershed and accumulate in the bottom sediments. Under certain conditions (low dissolved oxygen, agitation) nutrients are released back into the water column through the processes of diffusion and re-suspension. For the following discussion, internal nutrient loading refers to nutrient release by diffusion due to the difference in the nutrient concentrations in sediment porewater and the overlying water column and the release of nutrients by biogeochemical mineralization..

Lake Elsinore and Canyon Lake sediments were characterized for a number of properties, including particle size, carbon (C), sulfur (S) carbonate ($CaCO_3$) content and nutrient concentrations (total nitrogen (N) and total phosphorus (P)). The porewater samples were analyzed for ammonia nitrogen (NH_4-N) and soluble reactive phosphorus (SRP)[9] concentrations (Anderson, 2001, Anderson and Oza, 2003). Particle size is an important factor that determines nutrient distribution and nutrient release rates in sediment; fine-grained sediments tended to have a higher content of carbon (C), nitrogen (N), phosphorus (P), sulfur (S) and calcium carbonate ($CaCO_3$) relative to coarse-grained sediments.

Lake Elsinore Internal Nutrient Loading and Nutrient Budget

Three types of sediments were identified within Lake Elsinore. In <4 m of water, the sediments tended to be sandy, with little organic matter (Type I); at 6-7 m depth, sediments were finely textured with high organic matter and high nitrogen and phosphorus contents (Type III); and at the 4-6 m depth, the sediment was transitional Type II, with texture, carbon, nitrogen and phosphorus contents in between Type I and Type III sediments. For Lake Elsinore, the fine-grained, organic rich (Type III) sediment was estimated to occupy 1440 acres, or approximately one-half of the total sediment surface. Type I and II sediments each occupied approximately 25% of the lake bottom. The distribution of sediment in Lake Elsinore is shown in Figure 5-1. The chemical characteristics for Lake Elsinore sediments are summarized in Table 5-2.

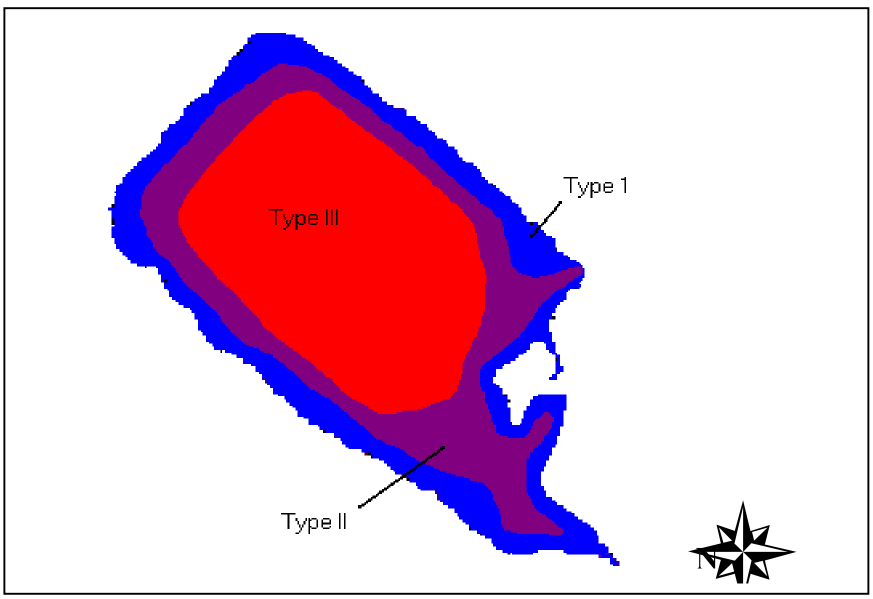


Figure 5-1. Distribution of sediment within Lake Elsinore by sediment type (modified from Anderson, 2001).

[9] SRP is soluble reactive phosphorus. It is equivalent to ortho-phosphate (P).

Table 5-2. Average sediment properties by Type for Lake Elsinore (from Anderson, 2001)

AVERAGE PROPERTY	Units	Type I		Type II		Type III	
		Mean	STDV	Mean	STDV	Mean	STDV
AREA	acres	750		810		1440	
Water Depth	m	2.8	1.1	4.9	0.9	6.3	0.6
Sand	%	70.8	31.2	29.5	15.4	4.1	4.0
Silt	%	19.7	23.6	48.1	11.9	44.8	6.8
Clay	%	9.5	11.7	22.3	5.4	51.2	6.3
Total C	%	1.07	1.44	3.04	0.86	5.97	0.39
Organic C	%	0.79	1.06	2.13	0.75	4.84	0.45
Inorganic C	%	0.28	0.42	0.90	0.20	1.14	0.26
CaCO3	%	2.34	3.46	7.53	1.66	9.5	2.2
Total N	%	0.10	0.12	0.27	0.07	0.53	0.03
Total S	%	0.14	0.30	0.53	0.28	1.18	0.08
Total P	mg/kg	425	209	781	165	916	73
Inorganic P	mg/kg	340	170	595	128	573	77
Organic P	mg/kg	84	97	196	104	342	71
Porewater							
Soluble Reactive P	mg/L	0.6	1.3	3.1	0.6	4.9	1.2
NH_4-N	mg/L	6.8	6.9	14.5	6.1	20.0	3.7

STDV = standard deviation

In order to determine the internal loading from the lake's sediments to the overlying water column, Dr. Anderson conducted laboratory core-flux experiments. A summary of the Lake Elsinore internal nutrient loading results are tabulated in Table 5-3.

Table 5-3. Internal nutrient loading to Lake Elsinore (2000-2001) (modified from Anderson, 2001)

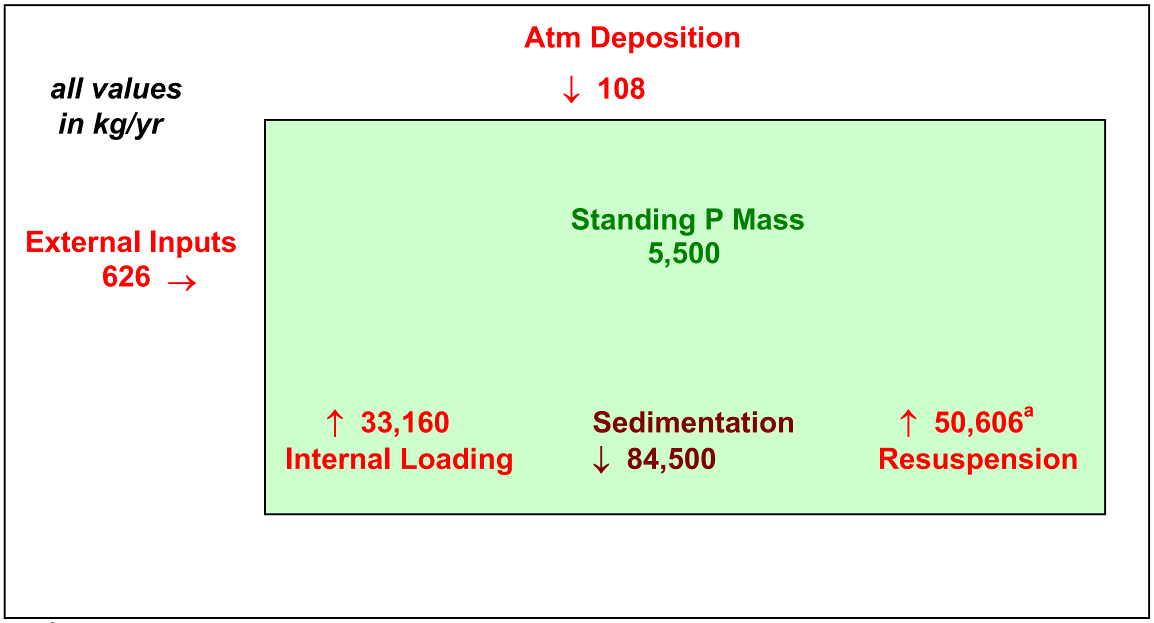
		Summer (6 mons)		Winter (6 mons)		Total
Sediment	Area (acres)	Average Flux $mg/m^2/d$	Loading kg	Average Flux $mg/m^2/d$	Loading kg	Loading kg
SRP						
Type I	750	1.9	1,040	0.1	50	1,100
Type II	810	11.0	6,590	11.8	7,060	13,650
Type III	1440	10.3	10,960	7.0	7,450	18,410
Annual Total						**33,160**
NH_4-N						
Type I	750	8.0	4,430	0.1	200	4,630
Type II	810	93.1	55,740	20.8	12,450	68,190
Type III	1440	91.4	97,280	25.6	27,250	124,530
Annual Total						**197,370**

Because of the anoxic conditions at the sediment-water interface, the dominant form of nitrogen released from sediment is ammonium nitrogen (NH_4-N). For Lake Elsinore, the core-flux results demonstrate significant releases of NH_4-N and soluble reactive phosphorus (SRP) from the Type II and Type III sediment. For all three types of sediments, the release rate of NH_4-N and SRP was lower in the winter than during the summer, probably due to higher temperatures in the summer. The release rates of SRP and NH_4-N for the Type II and Type III sediments were comparable, but the rate is much lower in the sandy, less organic rich (Type I) sediment. For the period of 2000-2001, the total nutrient internal loading to Lake Elsinore was 33,160 kg SRP and 197,370 kg NH_4-N per year.

In addition to internal nutrient loading, re-suspension of sediment due to wave action caused by wind and bioturbation by bottom dwelling organisms such as carp could also be an important source of internal nutrient load. Lake Elsinore also has high deposition rates for particulate-borne nutrients, which makes measurement of the resuspension rate difficult. Alternatively, resuspension was calculated using the formula:

> Nutrient load from resuspension = Σ loads going out of water column - external input – atmospheric deposition – internal loading
>
> (for phosphorus, the term "Σ loads going out of water column", equals the sedimentation load; for nitrogen, the term "Σ loads going out of water column", equals the sum of the sedimentation and denitrification load).

The result was that 50,606 kg of phosphorus was suspended (compared to the 84, 500 kg of phosphorus that was deposited) for the 2000-2001 period (Anderson, 2001). The phosphorus budget for the 2000-2001 period in Lake Elsinore is shown in Figure 5-2.

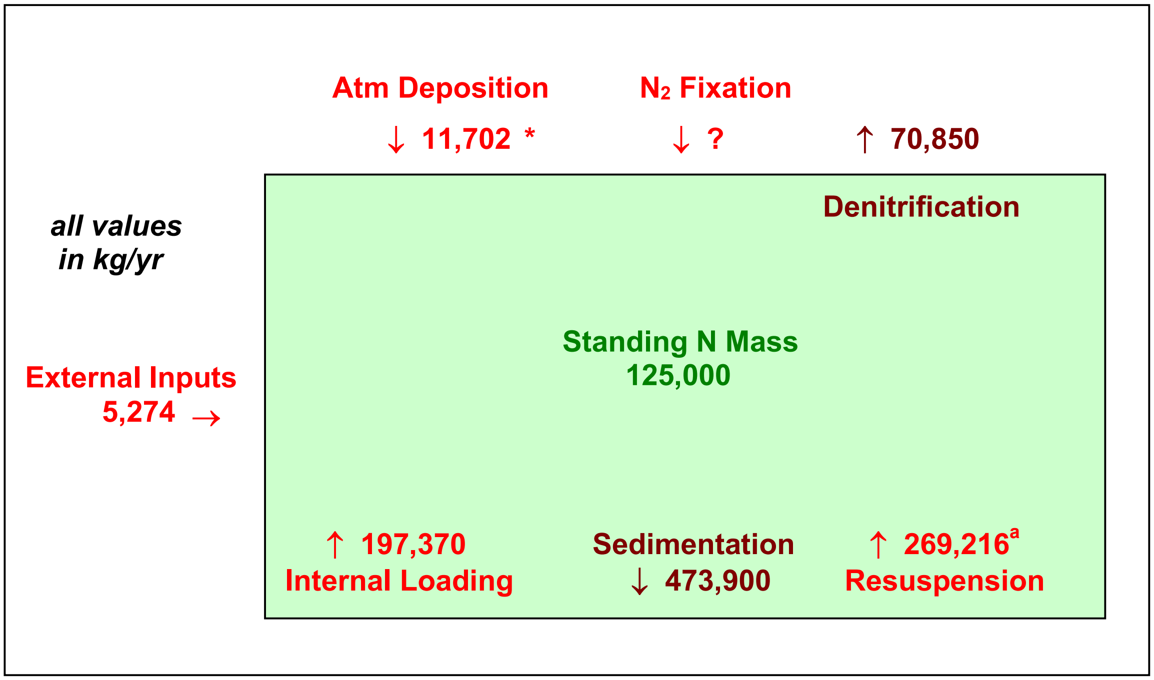


[a] Phosphorus loading from re-suspension was calculated by the formula: Resuspension = sedimentation – internal loading – external input – atmospheric deposition.

Figure 5-2. Lake Elsinore phosphorus budgets for 2000-2001 water year (Anderson, 2001).

As shown in Figure 5-2, the predominant source of phosphorus during the study period (a dry period for the lake) was the internal sources. External inputs, calculated by multiplying the flow and mean concentrations, constituted only a very small portion of the overall phosphorus loading to Lake Elsinore.

The nitrogen budget for Lake Elsinore during the 2000-2001 period was also determined, as shown in Figure 5-3. Similar to the phosphorus budget, internal loading contributed a much greater portion of the total budget (197,370 kg/yr) than the external sources (5,274 kg/yr). Re-suspension of bottom sediments added an additional 269,200 kg of nitrogen to the water column in the 2000-2001 period.



* Nitrogen deposition includes wet and dry deposition at a rate of 7.1 lbs./ac/yr. (Meixner, 2003, oral communication).
[a] Nitrogen loading from resuspension was calculated by the formula: Resuspension = sedimentation + denitrification – external input – internal loading

Figure 5-3. Lake Elsinore nitrogen budget for 2000-2001 period (modified from Anderson, 2001)

Canyon Lake Internal Nutrient Loading and Nutrient Budget

Similar to Lake Elsinore, three types of sediments were identified within Canyon Lake. Type I sediments, distributed in less than 4 m depth, were sandy with little organic matter. Type III sediments, found at 6-7 m depth, were finely textured with high organic matter and high nitrogen and phosphorus contents. Type II sediments, distributed at the 4-6 m depth, were transitional, with texture, carbon, nitrogen and phosphorus contents in between Type I and Type III sediments. For Canyon Lake, the transitional (Type II) sediments were estimated to occupy 143 acres, or 48% of the total sediment surface. Type I and III sediments occupied approximately 20% and 32% of the lake bottom, respectively. The distribution of sediment in Canyon Lake is shown in Figure 5-4. The chemical characteristics for Canyon Lake sediments are summarized in Table 5-4.

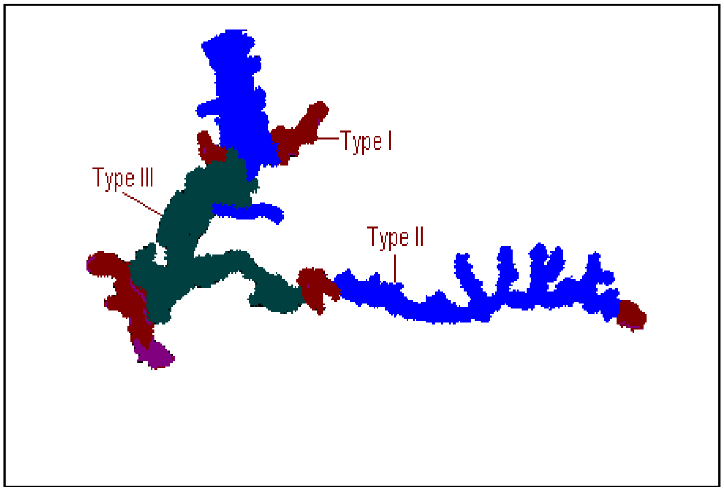


Figure 5-4. Sediment type distribution found in Canyon Lake (modified from Anderson and Oza, 2003)

Table 5-4. Average sediment properties by Type for Canyon Lake (from Anderson and Oza, 2003)

Average Property	**Units**	**Type I**		**Type II**		**Type III**	
Sediment		Mean	STDV	Mean	STDV	Mean	STDV
Area	acres	61.3		143.3		93.9	
Water Depth	m	4.2	2.8	3.9	2.4	8.7	3.1
Sand	%	45.1	19.1	2.7	2.9	2.8	3.7
Silt	%	40.6	17.1	49.1	4.5	33.8	4.6
Clay	%	14.3	3.0	48.2	5.7	64.5	3.5
Total C	%	2.4	1.2	4.0	0.4	4.2	0.5
Organic C	%	2.2	0.9	2.8	1.5	3.6	0.4
$CaCO_3$	%	2.2	2.5	4.4	4.0	4.7	1.6
Total N	%	0.3	0.1	0.4	0.0	0.5	0.0
Total S	%	0.4	0.2	0.7	0.2	0.9	0.2
Total P	mg/kg	437	128	780	69	937	96
Inorganic P	mg/kg	382	165	578	44	672	155
Organic P	mg/kg	55	98	202	60	265	111
Porewater							
SRP	mg/L	2.61	1.4	2.8	0.9	3.0	0.5
NH_4-N	mg/L	11.18	4.0	14.9	2.5	22.0	11.0

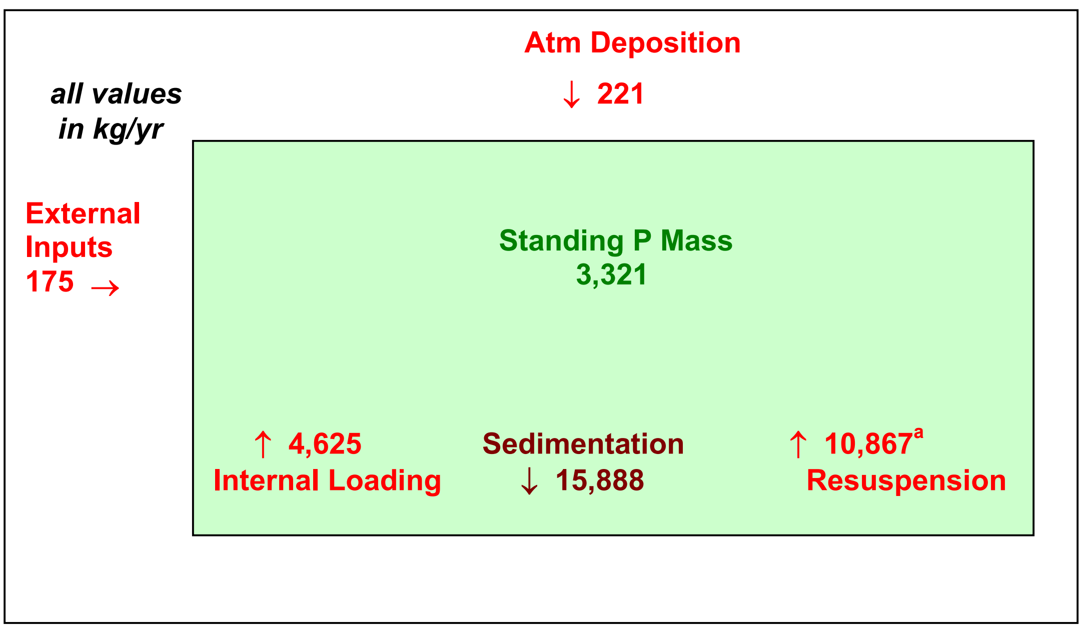
STDV = standard deviation

Similar to Lake Elsinore, Canyon Lake sediments released nutrients at high rates, with the SRP flux rate averaging 6.3, 15.1 and 6.5 mg/m^2/d for the Type I, II and III sediments, respectively (Table 5-5). Release of NH_4-N was found to be in the range of 22.7 to 34.8 mg/m^2/d. Internal nutrient loading rates of SRP and NH_4-N varied among sediment types. Unlike Lake Elsinore, no clear seasonal trend was observed in the nutrient release rates for Canyon Lake. Therefore, the average annual release rates for SRP and NH_4-N were used to calculate the internal loading for Canyon Lake. For water year 2001-2002, the total nutrient internal loading to Canyon Lake was 4,625 kg of SRP and 13,549 kg of NH_4-N.

Table 5-5. Internal nutrient loading to Canyon Lake (2001-2002) (modified from Anderson and Oza, 2003)

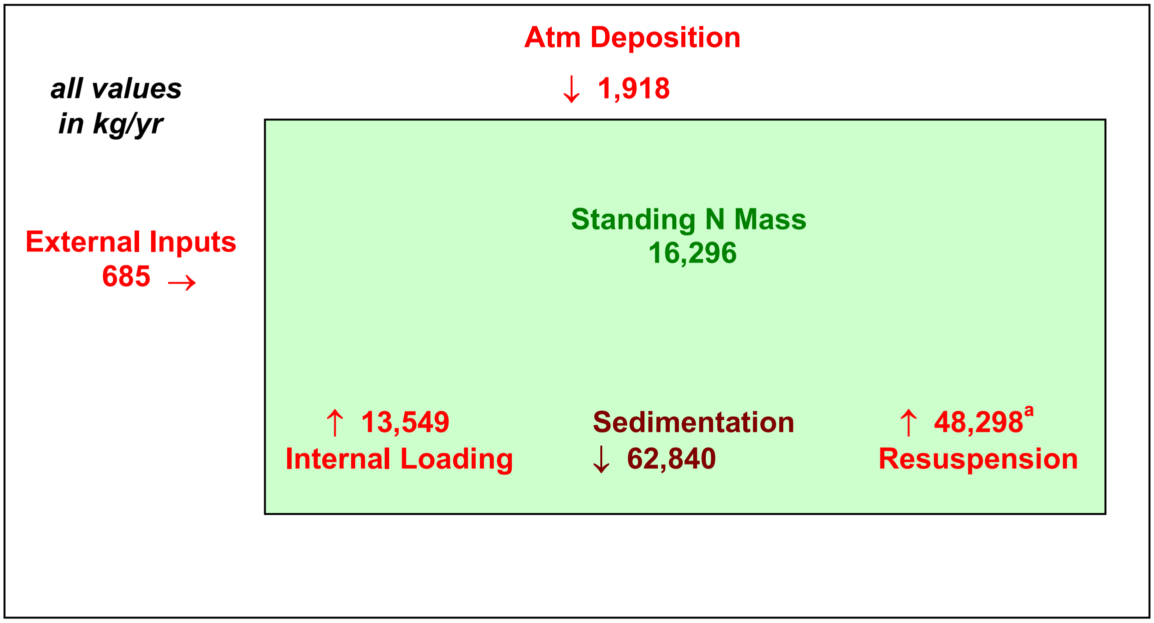
			Main Body		East Bay		Total
Sediment	Area Acres	Flux $mg/m^2/d$	Area Acres	Mass kg	Area Acres	Mass kg	kg
SRP							
Type I	61.3	6.3	47.8	446	14.4	134	580
Type II	143.3	15.1	64.8	1,444	74.5	1,664	3,108
Type III	93.9	6.5	82.6	795	14.8	142	937
Annual Total							**4,625**
NH_4-N							
Type I	61.3	22.7	47.8	1,607	14.4	483	2,090
Type II	143.3	34.8	64.8	3,328	74.5	3,836	7,164
Type III	93.9	29.8	82.6	3,643	14.8	652	4,295
Total							**13,549**

In addition to nutrient flux, sedimentation and sediment-re-suspension are important processes controlling internal nutrient cycling in Canyon Lake. Canyon Lake phosphorus and nitrogen budgets for the 2001-2002 period are shown in Figures 5-5 and 5-6.



[a] Phosphorus loading from re-suspension was calculated by the formula: Resuspension = sedimentation – internal loading – external input – atmospheric deposition.

Figure 5-5. Canyon Lake phosphorus budget for 2001 – 2002 period (modified from Anderson and Oza, 2003)



* Nitrogen deposition includes the wet and dry deposition at a rate of 7.1 lbs./ac/yr. (Meixner, 2003, oral communication). [a] Nitrogen loading from resuspension was calculated by the formula: Resuspension = sedimentation +denitrification – external input – internal loading

Figure 5-6. Canyon Lake nitrogen budget for 2001 – 2002 period (modified from Anderson and Oza, 2003)

It is important to note that the internal nutrient loading to Lake Elsinore and Canyon Lake was determined for the specified study period, i.e., water year 2000-2001 for Lake Elsinore and water year 2001-2002 for Canyon Lake. This period represents a dry hydrological time period when there was limited contribution of nutrients from the watershed (external sources) and no outflow from either lake. No data are available to determine the internal nutrient loading under other hydrologic conditions. It is possible that the internal loading would increase after heavy rainfall when the San Jacinto River carries nutrient rich water to the lakes. Further study and modeling is required to estimate the long-term internal loading to Lake Elsinore and Canyon Lake under various hydrologic regimes. However, for the development of this TMDL, the best available data are used with the recognition that additional studies are needed.

It is also important to note that the nutrient budgets developed during the sediment study periods (2000-2001 for Lake Elsinore and 2001-2002 for Canyon Lake) reflected that during a dry year, the magnitude of the internal nutrient loading is much greater than the external nutrient input. At the time when this TMDL work was initiated, no data existed to quantify the historical external nutrient loads in the San Jacinto River watershed. Therefore, a monitoring program was designed and implemented, and a model simulation approach was used to estimate external loads from various sources under other hydrologic conditions. The model approach is described next.

5.2 External Nutrient Source Assessment

Hydrology of the San Jacinto River Watershed and Identification of Representative Hydrological Scenarios

As described previously, all streams in the San Jacinto River watershed are ephemeral. Under normal dry periods, the mainstem of the San Jacinto River is dry, contributing no flow to Canyon Lake, and upstream pollutants do not reach the lakes. External sources contribute nutrients to the lakes via storm flows only during the wet season (October through April). Even in the wet season, in most years, the main stem of the San Jacinto River does not flow all the way to Canyon Lake. An analysis of the stream flow data collected at the US Geological Survey (USGS) Station #1170500 (located between Canyon Lake and Lake Elsinore) from 1917 to 2003, indicates that the flow to Lake Elsinore is characterized by extended periods of drought interrupted by major storm flows (Figure 5-7). This hydrologic regime is reflected in changes in the elevation of Lake Elsinore (see Figure 2-2), as well as changes in nutrient loading to the lake (see further discussion below).

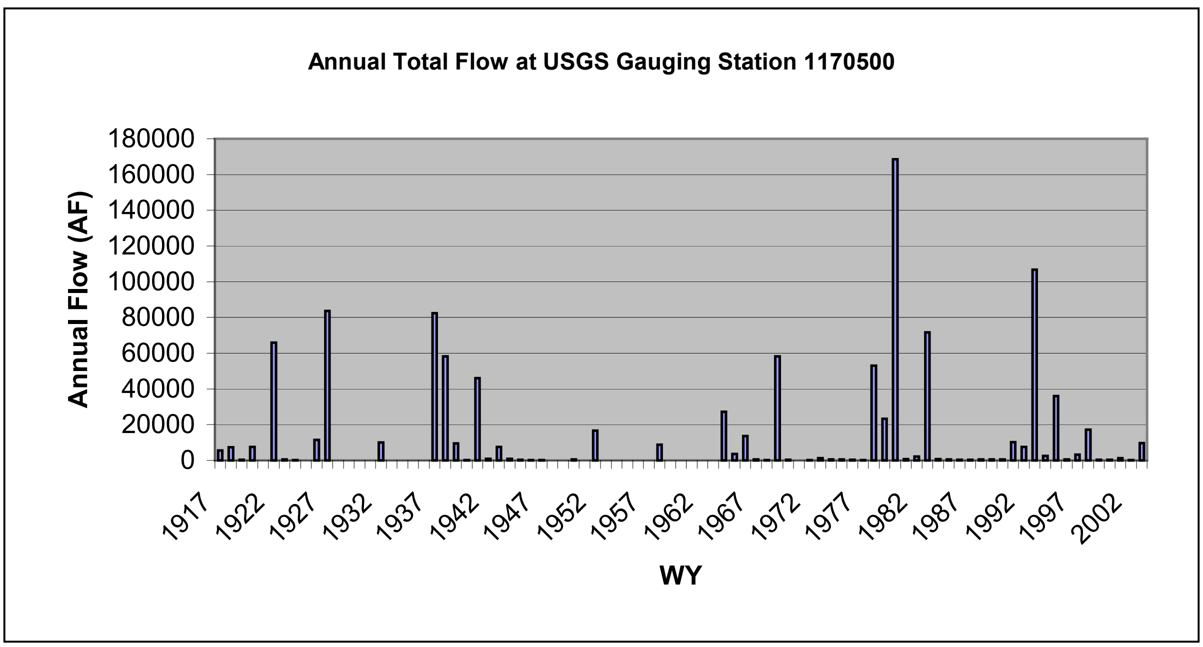


Figure 5-7. Annual total flow at the USGS gauging station 1170500 (located between Canyon Lake and Lake Elsinore) during the record period of 1917 - 2003

Due to the ephemeral nature of the San Jacinto River system, the location of the various land use sources within the watershed is a major factor affecting the ultimate delivery of nutrients to Canyon Lake and Lake Elsinore. Under average rainfall conditions, urban development and agricultural land practices in the central portion of the San Jacinto River watershed below Mystic Lake (including Perris Valley and the Salt Creek sub-watershed) have the greatest impact on the water quality of Canyon Lake. However, during periods of heavy rain and/or extended periods of rainfall, the storage capacity of Mystic Lake is exceeded and surface flow from open space areas in the headwaters, stormwater runoff from the cities of Hemet and San Jacinto, and agricultural runoff upstream of Mystic Lake, reach Canyon Lake. Further, if the rainfall is significant, Canyon Lake may overflow into Lake Elsinore. Other than overflows from Canyon Lake during significant rain events, external nutrient loads to Lake Elsinore are dominated by local watershed sources downstream of Canyon Lake.

To evaluate the variability of nutrient loading to Canyon Lake and Lake Elsinore due to the various hydrologic conditions that occur in the San Jacinto watershed and the existence of nested water bodies in this large drainage basin (Lake Hemet, Mystic Lake, Canyon Lake), three scenarios (*i.e.*, wet, moderate and dry) were simulated for the period of 1991 – 2000, by a water quality model (Table 5-6) (see further discussion below). Under wet conditions, the main stem of the San Jacinto River flows into and fills Mystic Lake, which then spills to Canyon Lake. Canyon Lake also spills to Lake Elsinore. Depending on the existing elevation, Lake Elsinore could fill and spill to Temescal Wash. The representative year for the wet condition during the model period is water year 1998. The moderate condition is when the main stem of the San Jacinto River doesn't flow all the way to Canyon Lake. Flows from Salt Creek and the Perris Valley Storm Drain make up the water to Canyon Lake. Canyon Lake may have moderate spills to Lake Elsinore. The representative water year during the model period is water year 1994. Under dry conditions, the flow from the San Jacinto River watershed never reaches Lake Elsinore. The external nutrient loads to the lake come from the runoff from the local watershed surrounding the lake, as represented by water year 2000.

Table 5-6. Three hydrologic conditions simulated by LSPC model

Scenario	Hydrologic Condition	Representative Water Year	Description
I	Wet	1998	Both Canyon Lake and Mystic Lake overflow; flow at the USGS gauging station 11070500 was 17,000 acre-feet
II	Moderate	1994	No Mystic Lake overflow; Canyon Lake overflowed, flow at the USGS gauging station 11070500 was 2,485 acre-feet
III	Dry	2000	No overflows from Mystic Lake or Canyon Lake, flow at the USGS gauging station 11070500 was 371 acre-feet

Table 5-6 also identifies the flows measured at the USGS gauging station 11070500. The annual flow at the gauging station in 1998 was approximately seven times the flow for 1994, which in turn, was nearly seven times the flow measured in 2000.

The relative flow frequency of each of the scenarios was determined using the annual total flow data (for each water year) at the USGS gauging station #1170500. Of the 87 years of record (1917-2003), there were 14 "wet" years (those years with flows greater than or equal to what occurred in 1998); there were 37 "dry" years (flows less than or equal to that measured in water year 2000), and there were 36 "moderate" years (flows greater than that measured in 2000 [dry], but less than measured in1998 [wet]). Table 5-7 lists the relative flow frequency of the wet, moderate and dry scenarios.

Table 5-7. Relative flow frequency at the USGS gauging station #1170500 during 1917 – 2003 period

Hydrologic Scenario (Category)	Years in Each Category	Relative Frequency (%)
Wet	14	16
Moderate	36	41
Dry	37	43

At the present, it is difficult to predict the magnitude/nature of the storms necessary to result in the three hydrological conditions, particularly the wet scenario (scenario I). There are a variety of combinations of events that could lead to a spill from Mystic Lake, from an extremely rare event (a 1,000 year, single day event) to a series of very small storms over a period of a month or so. For example, the '69, '80 and '93 events that led to overflows of Mystic Lake were relatively insignificant in terms of rainfall intensity for short duration time periods. But the storms lasted for a long time (weeks, and a month). It should also be noted that in 1969 and 1980, there were a series of storms that inundated the Mystic Lake area prior to the storms that generated enough flow to push the water out of Mystic Lake.

While prediction is difficult, the three hydrologic scenarios are based on historical data and observations by the Riverside County Flood Control and Water Conservation District. They are real situations with significant impacts on the magnitude of nutrient loads to both Lake Elsinore and Canyon Lake (as discussed in the following section). As more data are collected and detailed hydrologic modeling analysis is conducted in the future, flow prediction may be possible, and the TMDL can be revised to reflect the new information.

Nutrient Source Assessment by Model Simulation

Model analysis to determine external nutrient source loadings was conducted by Tetra Tech, Inc. with funding support from the Lake Elsinore and San Jacinto Watershed Authority through a Clean Water Act Section 205(j) grant and a Proposition 13 grant (Tetra Tech, Inc., 2003). The watershed modeling analysis utilized existing data from all sources and represents the first effort to quantify nutrient loads from various sources and various locations in the San Jacinto River watershed. Data collected from the TMDL monitoring program conducted during 2000 to 2003 were used to calibrate and validate the model results.

To quantify the nutrient loads to both Canyon Lake and Lake Elsinore, as well as to calculate the load contributions from sources in the watershed, Tetra Tech, Inc. selected US EPA's Loading Simulation Program C++ (LSPC) model as the watershed model platform. The LSPC model has the ability to simulate all nutrient sources in the watershed, routing flow and water quality through stream networks to Canyon Lake and Lake Elsinore. To simulate Canyon Lake water quality, US EPA's Environmental Fluid Dynamics Code (EFDC) was utilized. The EFDC model simulated Canyon Lake hydrodynamics, as well as simplified nutrient processes in order to predict Canyon Lake overflow volume and the resulting contribution of nutrients in water delivered to Lake Elsinore.

5.2.1 Nutrient Loading to Canyon Lake

Annual total nitrogen and total phosphorus loads to Canyon Lake simulated by the LSPC model for 1991 to 2000 are shown in Table 5-8. The annual phosphorus and nitrogen loads to Canyon Lake varied from one year to another, depending on the amount of runoff generated by rainfall events. Over the 10-year period, phosphorus load ranged from 1,674 kg/yr to 69,158 kg/yr and averaged 17,711 kg/yr; nitrogen load ranged from 6,381 kg/yr to 226,808 kg/yr and averaged 53,192 kg. As shown in Figures 5-8 and 5-9, during the 10-year period, only three years, 1993, 1995, and 1998 (all wet years), generated nutrient loads greater than the average annual loads. In fact, the sum of nutrient loads for dry years (1991, 1992, 1994, 1996,1997, 1999, and 2000) was less than the nutrient loads for the 1993 wet year alone. As expected, very wet years contribute much greater nutrient loads from the watershed than drier years.

Table 5-8. Simulated annual nutrient loads to Canyon Lake (water years) (from Tetra Tech, 2003)

Water Year*	Precipitation At Elsinore (in)+	TP (kg)	TP (lbs.)	TN (kg)	TN (lbs.)
1991	11.90	13,422	29,591	36,688	80,883
1992	11.20	5,169	11,396	19,094	42,094
1993	21.60	69,158	152,465	226,808	500,020
1994	9.5	2,699	5,951	10,904	24,039
1995	17.30	32,619	71,912	73,950	163,029
1996	6.70	2,519	5,554	7,617	16,793
1997	7.2	4,799	10,580	8,480	18,696
1998	22.30	43,031	94,865	130,509	287,720
1999	3.80	2,020	4,454	6,381	14,067
2000	6.20	1,674	3,690	11,485	25,319
average	**11.77**	**17,711**	**39,046**	**53,192**	**117,266**
max	22.3	69,158	152,465	226,808	500,020
min	3.8	1,674	3,690	6,381	14,067
standard deviation	6.54	23,123	50,977	72,863	160,634
median	**10.35**	**4,984**	**10,988**	**15,289**	**33,707**

*A water year runs from October 1 through September 30 the next year.
+ Annual rainfall data are from July 1 through June 30 the next year (Data source: Riverside County Flood Control and Water Conservation District).

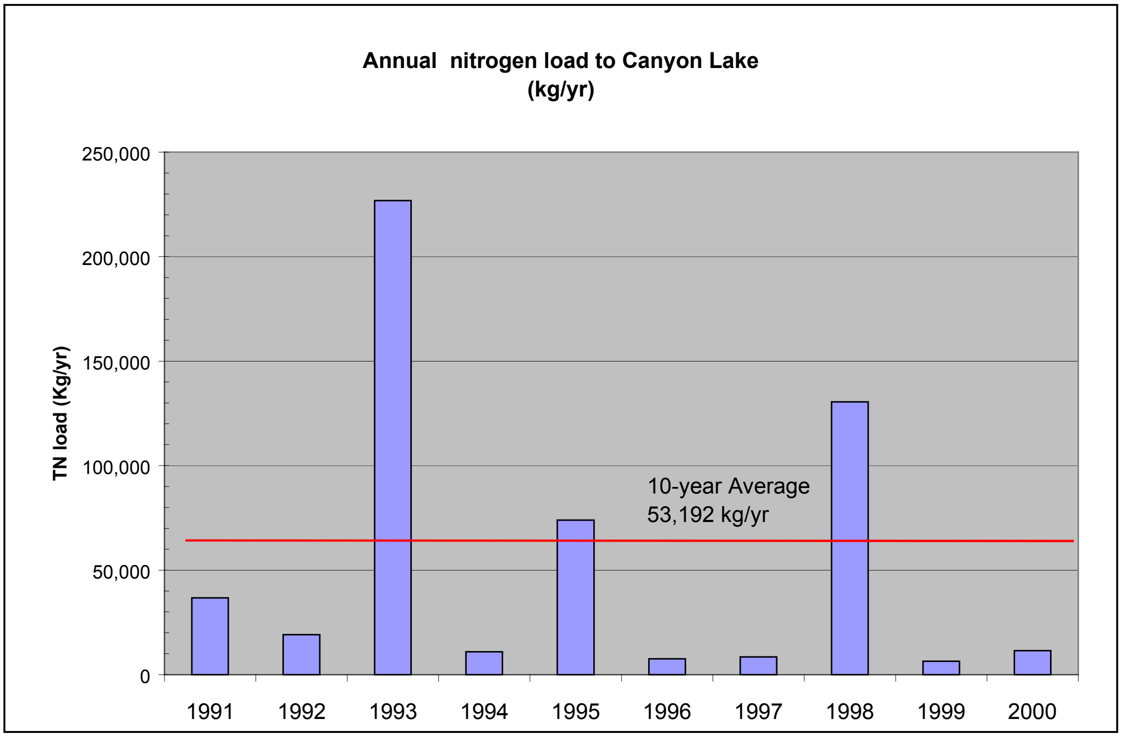


Figure 5-8. Modeled nitrogen load to Canyon Lake from 1991 through 2000 (data from Tetra Tech, 2003)

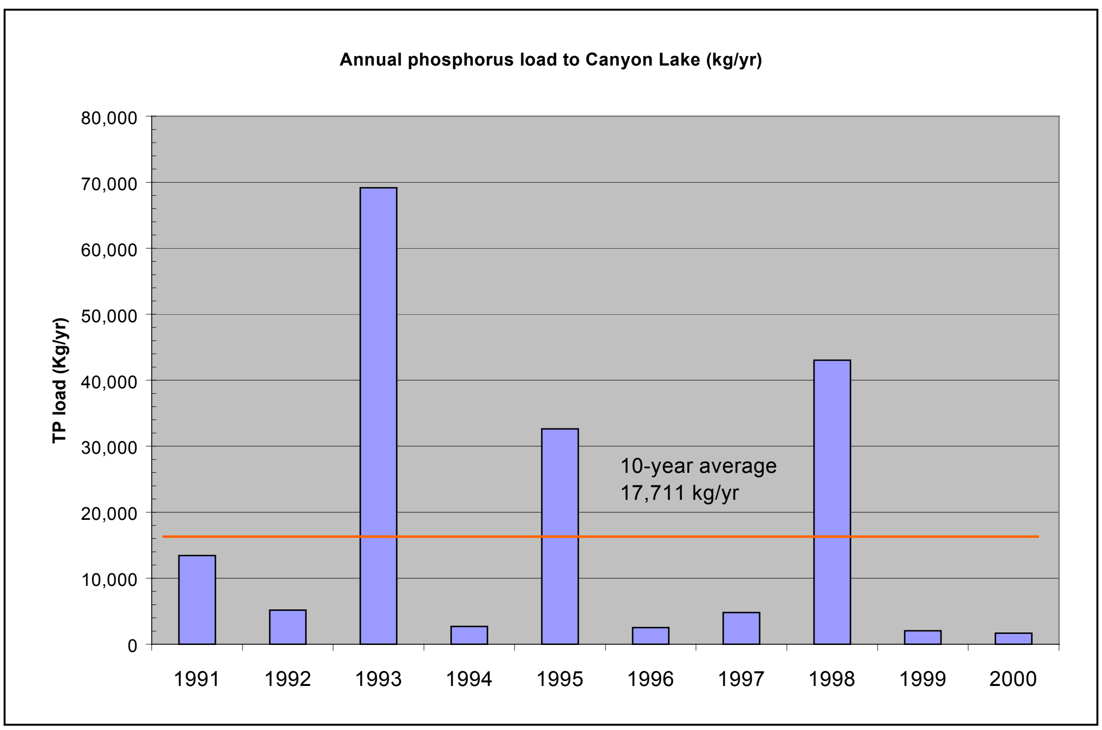


Figure 5-9. Modeled phosphorus load to Canyon Lake from 1991 through 2000 (data from Tetra Tech, 2003)

5.2.2 Nutrient Loading to Lake Elsinore

Nutrient loads to Canyon Lake were routed through the lake using the EFDC model to simulate the nutrients exported to Lake Elsinore. Due to the long time required for running the EFDC model, only three years were simulated to represent the three scenarios discussed previously (Table 5-6). The LSPC model was used to simulate the nutrient loads from the local watershed of Lake Elsinore. The total nutrient loads to Lake Elsinore are the sum of the loads from the local watershed and the load exported from Canyon Lake, as simulated by the EFDC model.

Annual loads of total nitrogen and total phosphorus to Lake Elsinore for each modeled water year are summarized in Table 5-9. Both the nitrogen and phosphorus loads to Lake Elsinore in 1998 (wet year) were more than two orders of magnitude greater than those for the water years 1994 and 2000 (moderate and dry years). As shown in Table 5-9, a significant amount of nutrient input to Lake Elsinore came from Canyon Lake.

Table 5-9. Simulated annual external nutrient loads to Lake Elsinore for three hydrologic scenarios (all numbers in kg/yr)

Re-presentative Water Year	Total Nitrogen				Total Phosphorus			
	Into Canyon Lake	From Canyon Lake	Local Lake Elsinore	Total to Lake Elsinore	Into Canyon Lake	From Canyon Lake	Local Lake Elsinore	Total to Lake Elsinore
1998	130,510	420,133	11,980	432,114	43,031	99,576	1,984	101,559
1994	10,904	17,233	1,329	18,562	2,700	562	227	789
2000	11,485	455	327	781	1,674	414	49	464

Adapted from Tetra Tech, 2003.

5.2.3 Assessment of Spatial and Land Use Loading Effects

Under moderate and dry conditions, the San Jacinto River mainstem does not flow and watershed nutrients are retained in the upper portions of the watershed upstream of Mystic Lake. However, localized sources as well as contributions from areas downstream of Mystic Lake do result in the transport of nutrients to the lakes each year regardless of rainfall amounts. Furthermore, there are cumulative impacts to the lakes due to buildup of nutrients in the upper watershed and the eventual delivery of these nutrients to the lakes.

To analyze the spatial variability in nutrient loading, the San Jacinto River watershed was divided into 9 zones. Figure 5-10 depicts the location of these zones. To easily track the impact of Mystic Lake overflows on nutrient transport, the load from Zone 7 is summarized as the load exported from Mystic Lake. If the load from Zone 7 is zero, Mystic Lake did not overflow and thus, no nutrient load was transported to the lower watershed. As an example, for scenarios II and III identified in Table 5-6 as moderate and dry year conditions, respectively, Zone 7 resulted in no net loading to the lower watershed since Mystic Lake did not overflow. Note that for scenario II and III, upstream nutrient loading is still reported for zones 8 and 9. For these scenarios, the nutrient loads exported from Zones 8 and 9 are stored in Mystic Lake.

Zone 2 nutrient loading to Canyon Lake includes the total loading from upstream, combined with local tributary loading from the area within the Zone 2 boundary, minus the losses resulting from mineralization, groundwater infiltration, and plant uptake. Total watershed nutrient loading to Lake Elsinore is represented by Zone 1 loading that includes the load exported from Canyon Lake and the load from the local area within the Zone 1 boundary. Total nitrogen and total phosphorus loadings for these 9 zones under the 3 simulated hydrological regimes are depicted in Figures 5-11 through 5-16. Relative percentages of nitrogen and phosphorus from the various nutrient sources are also depicted. Note that the nutrient loads are expressed in lbs in these figures, while through out the rest of this document, nutrient loads are expressed in kg. Nutrient loads to Zone 1 are not shown in these Figures because calculation of these loads requires simulation using both the LSPC and EFDC models, which was done only after the construction of the diagrams.

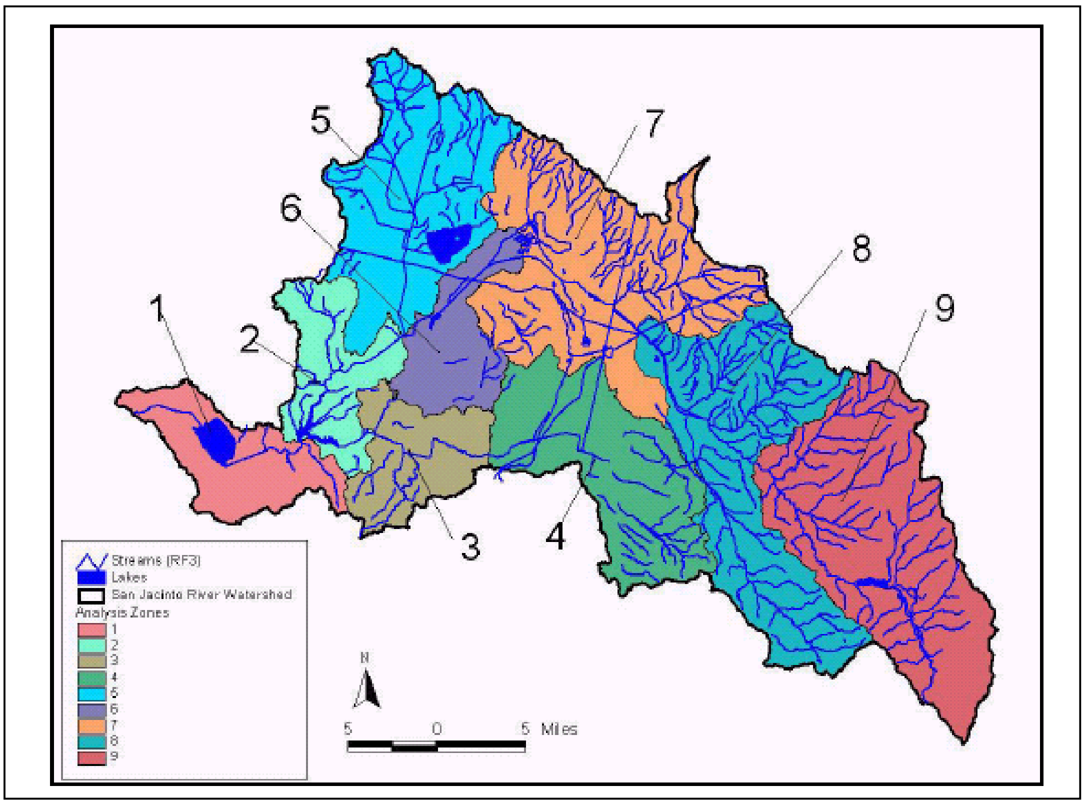


Figure 5-10 Watershed analysis zones (Tetra Tech Inc., 2003)

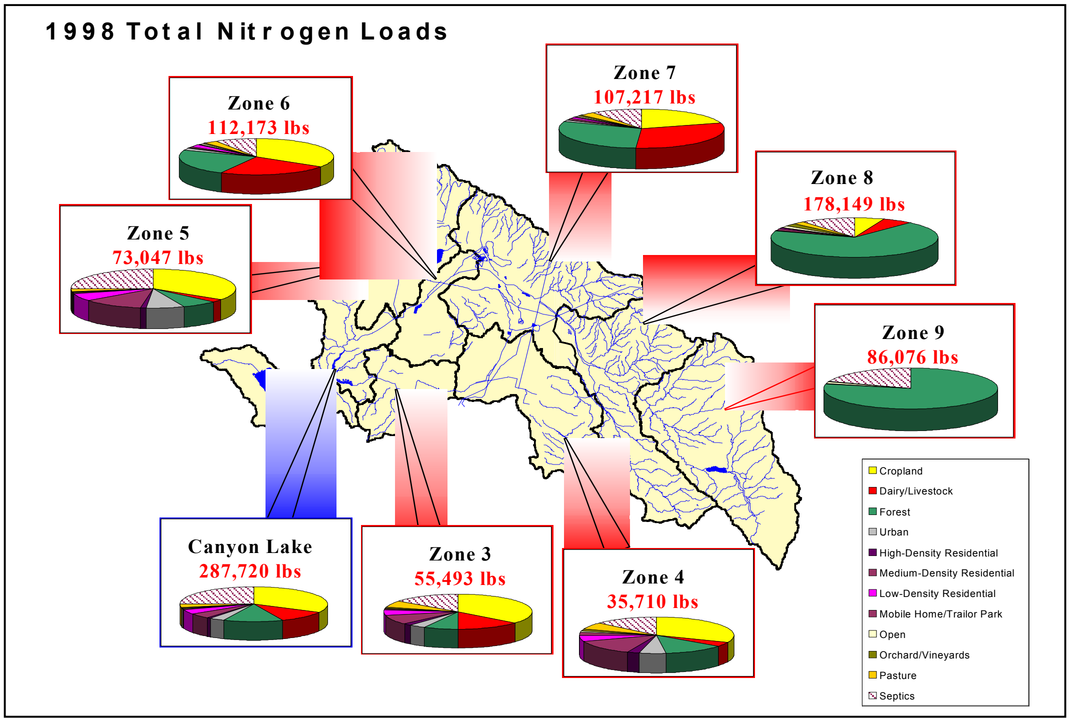


Figure 5-11 Simulated total nitrogen load in 1998 (Scenario I: wet year) (Tetra Tech Inc., 2003)

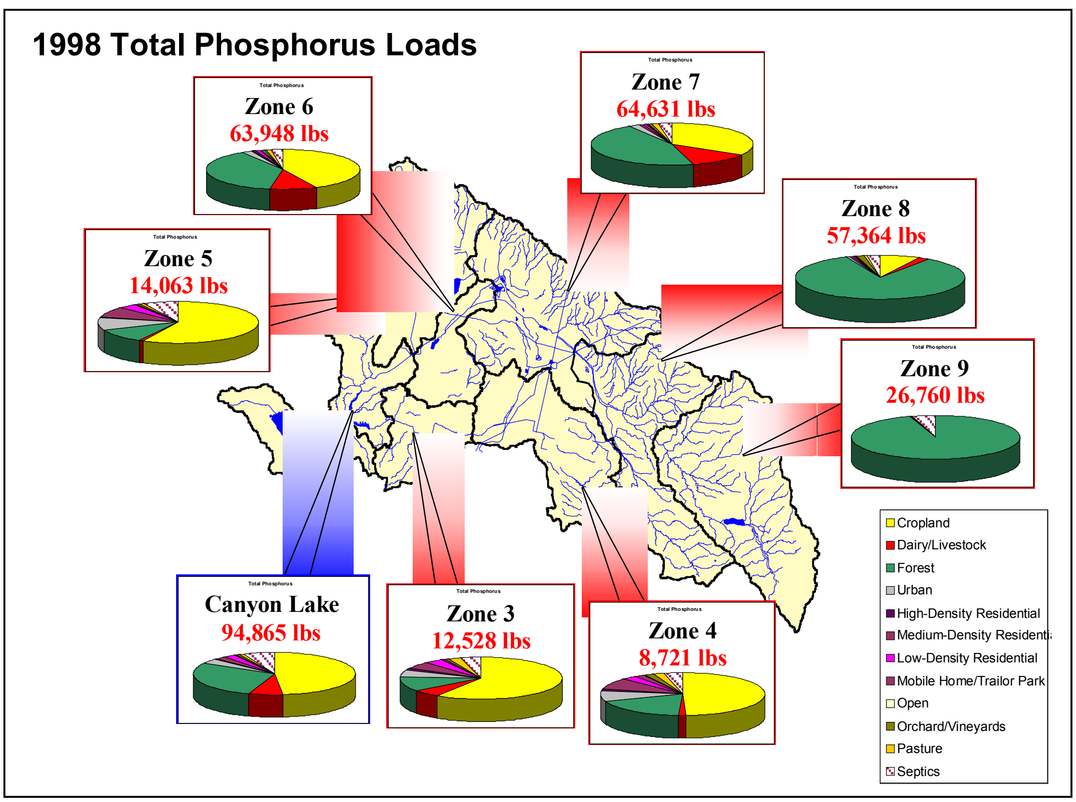


Figure 5-12. Simulated total phosphorus load in 1998 (Scenario I: wet year) (Tetra Tech Inc., 2003)

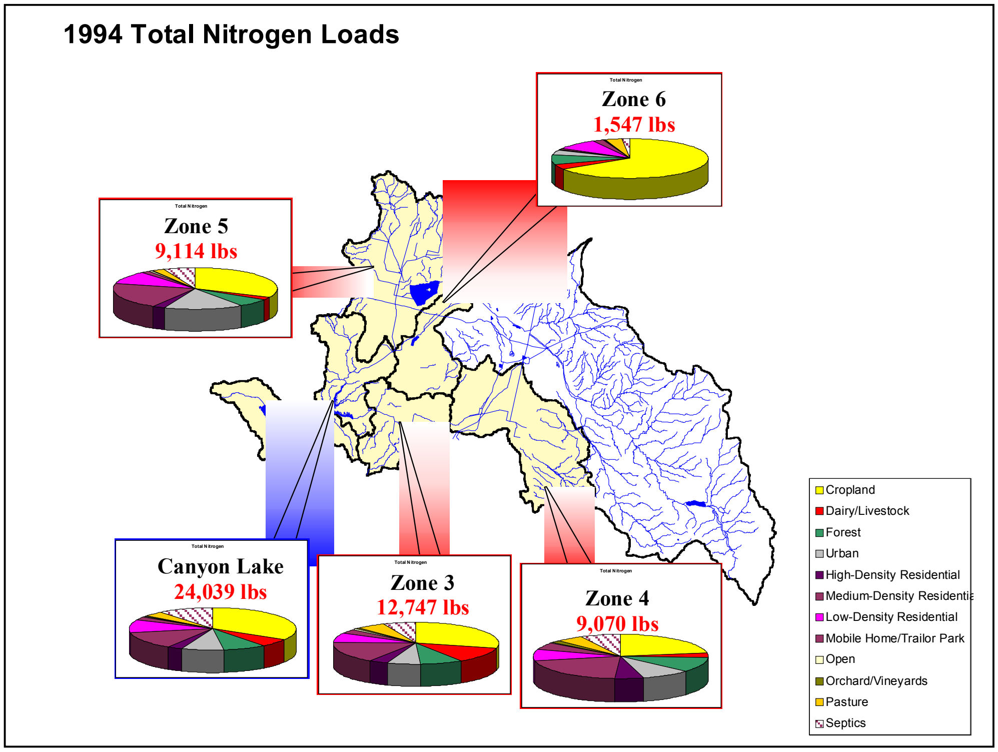


Figure 5-13 Simulated total nitrogen load 1994 (Scenario II: moderate year) (Tetra Tech Inc., 2003)

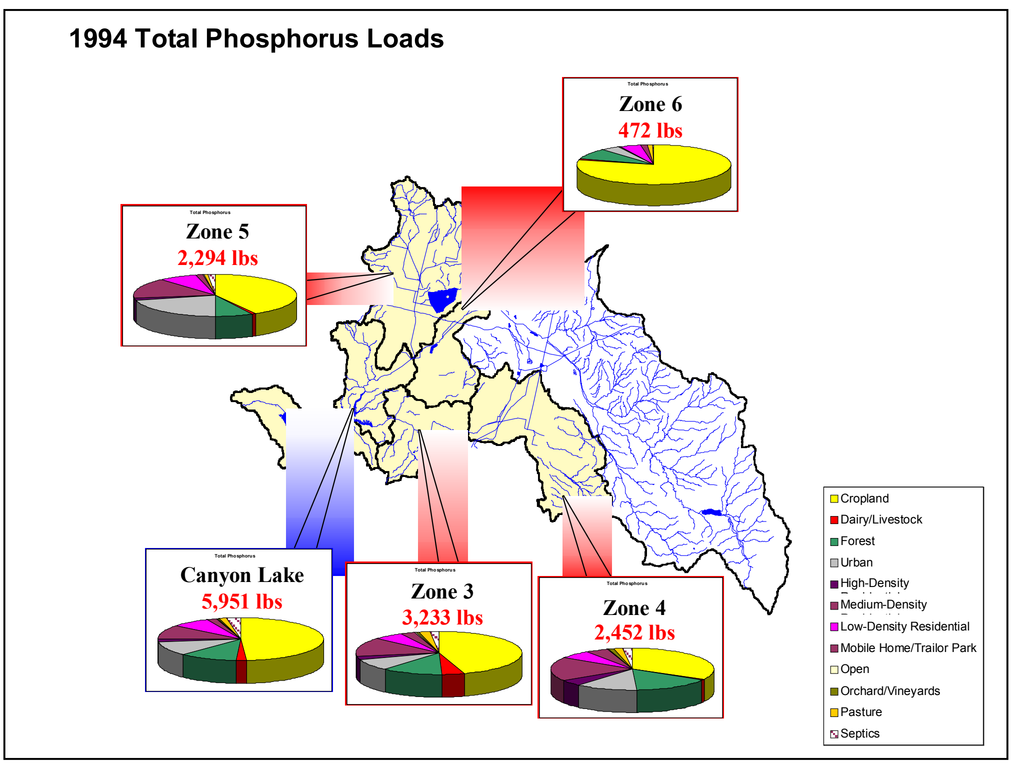


Figure 5-14. Simulated total phosphorus load 1994 (Scenario II: moderate year) (Tetra Tech Inc., 2003)

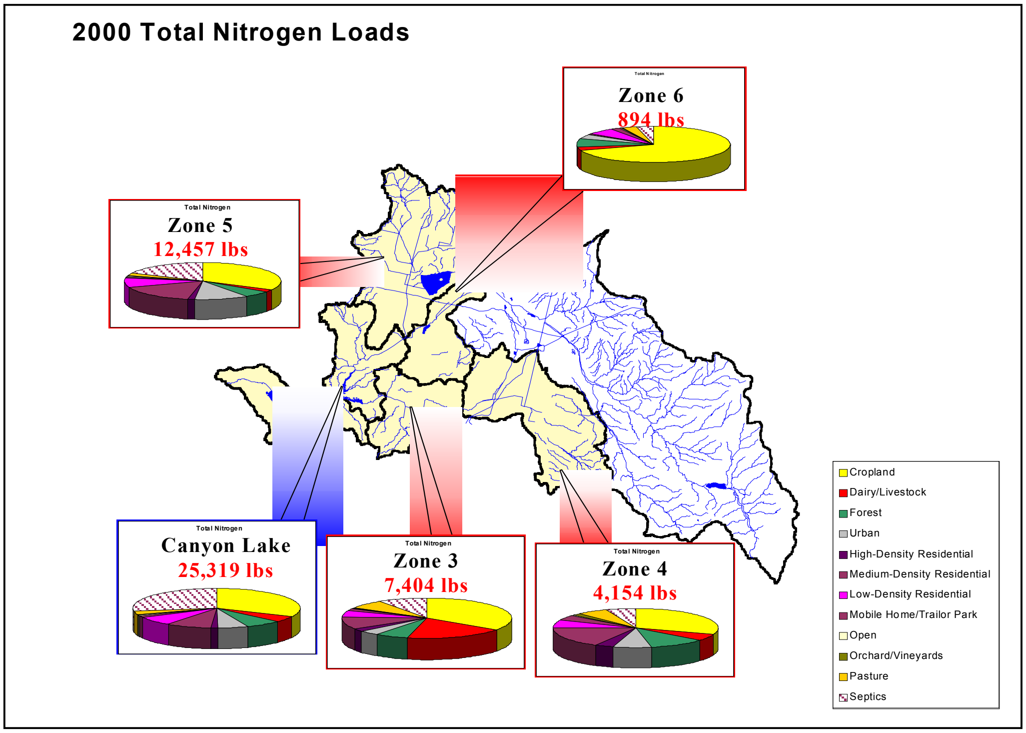


Figure 5-15 Simulated total nitrogen load in 2000 (Scenario III: dry year) (Tetra Tech Inc., 2003)

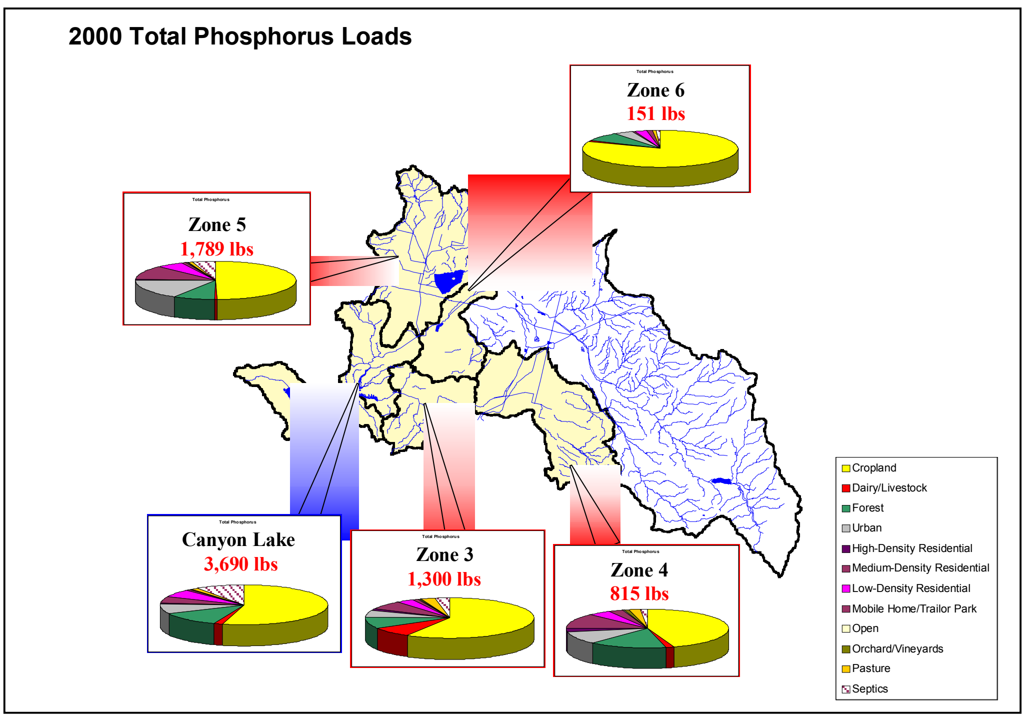


Figure 5-16 Simulated total phosphorus load in 2000 (Scenario III: dry year) (Tetra Tech Inc., 2003)

5.3 Summary of Nutrient Loads from All Sources

To determine the nutrient contribution from all potential sources, several assumptions had to be made. First, it was assumed that atmospheric deposition is constant for both lakes. Based on studies by Anderson (2001) and Anderson and Oza (2003), atmospheric deposition constituted a very small portion of the year 2000-2001 total nutrient loads to Lake Elsinore and the year 2001-2002 loads to Canyon Lake, irrespective of the amount of precipitation. Therefore the atmospheric deposition rates for nitrogen and phosphorus from these studies were used without adjusting for precipitation for individual years. The phosphorus load from atmospheric deposition was calculated by multiplying the lake surface area with a literature value for wet phosphorus precipitation rate for the study period. Because the studies for Lake Elsinore and Canyon Lake were conducted in two different years, the two wet phosphorus precipitation rates were used. Nitrogen load from atmospheric deposition includes wet precipitation determined in the same fashion as for phosphorus, and dry deposition determined by a study conducted in the Newport Bay watershed (Meixner, 2003, personal communication). This assumption is clearly subject to future refinement based on additional data evaluation during wet years.

Second, it was assumed that the internal nutrient release rate is constant. As discussed in Section 5.2, this assumption needs to be verified with further studies. For the present discussion, the Canyon Lake SRP release rate of 4,625 kg/yr and NH_4-N release rate of 13,549 kg/yr were used for the three scenarios (Anderson and Oza, 2003). For Lake Elsinore, the release rate assumed is 197,370 kg/yr total nitrogen and 33,160 kg/yr total phosphorus (Anderson, 2001).

Third, nutrient sources were aggregated by land use type. Agricultural sources include cropland, orchards/vineyards, and pastures; urban sources include mobile home/trailer parks, industrial facilities, highways and high-density, medium-density, and low-density residential; and CAFO sources are dairy and/or livestock. Open space/forest, septic systems, atmospheric deposition and internal nutrient loading (either from Canyon Lake or Lake Elsinore) are considered as separate categories.

Lastly, the LSPC model was never calibrated for the wet scenario due to the lack of data. The TMDL monitoring program in the watershed has been conducted in the past few years, which have been dry. No data existed for the model to be calibrated for the wet scenario when Mystic Lake spills and upper watershed nutrient loads are conveyed downstream to Canyon Lake and Lake Elsinore. As a matter of fact, the simulated flow to Lake Elsinore in 1998 was much greater than the measured flow at the USGS gauging station 1107050. Measures have been taken to reconcile the discrepancy. However, until empirical data are collected for the wet condition, the nutrient loads simulated by the LSPC are the best available data and have thus been used in the development of this TMDL.

For the three modeled hydrologic scenarios, Tables 5-10a, 5-10b and 5-10c lists the phosphorus and nitrogen loads by all potential sources to both lakes. The nutrient loads from external sources (Agriculture, Urban, CAFO, Open/Forest, and Septic Systems) were simulated by the LSPC model. Internal loading in Lake Elsinore (LE) and Canyon Lake (CL) was derived from the studies by Anderson (2001) and Anderson and Oza (2003). “Export from Canyon Lake” was simulated by the EFDC model (Tetra Tech., Inc., 2003). Limited amounts of recycled water

(<5000 acre-feet) have been discharged to Lake Elsinore since June 2002 to compensate for water loss through evaporation. Recycled water discharges, authorized pursuant to NPDES permits issued to EVMWD and EMWD, are part of a pilot study to evaluate the impact of increased lake elevation on water quality in Lake Elsinore. The nutrient loads from the recycled water were calculated using the total phosphorus and total nitrogen concentrations of 2 mg/L and 8 mg/L, respectively (Anderson and Nascimento, 2003). A study by CH2M Hill (2004) estimated that Lake Elsinore, on average, needed 3,300 AFY of recycled water to offset the evaporation loss. In the worst-case scenario, the lake needs 8,800 AFY recycled water (CH2M Hill, 2004). An average of 6,500 AFY was used to estimate the amount of nutrients that would have entered the lake if this amount of recycled water were to be discharged into the lake.

Canyon Lake periodically needs supplemental water to maintain the minimum legal requirement of the lake elevation (above 1372’). The source of the water is from the Colorado River water. The data available to staff is the most recent addition in April 2002, when approximately 1006 AF of water was added to Canyon Lake. The measured nitrogen and phosphorus concentrations were 0.2 mg/L and non-detect, respectively (EVMWD, personal communication, 2002). The calculated nutrient load from the supplemental water to Canyon Lake is 248 kg/yr nitrogen (see Tables 5-10a, 5-10b and 5-10c).

Table 5-10a. Total nutrient loads to Canyon Lake and Lake Elsinore for the wet scenario (all numbers in kg/yr)

Scenario I: Wet Condition - Both Mystic Lake and Canyon Lake Overflowed (WY 1998)

	Total Nitrogen				Total Phosphorus			
Nutrient Sources	Into Canyon Lake	From CL to LE	Local LE Watershed	Into Lake Elsinore	Into Canyon Lake	From CL to LE	Local LE Watershed	Into Lake Elsinore
Agriculture	47,452	47,452	1,563	49,014	21,590	21,590	277	21,867
Urban	18,337	18,337	2,531	20,868	3,885	3,885	548	4,432
CAFO	14,340	14,340	0	14,340	2,875	2,875	0	2,875
Open/Forest	17,591	17,591	2,351	19,943	12,068	12,068	789	12,857
Septics	32,790	32,790	5,536	38,326	2,613	2,613	370	2,984
subtotal of LSPC simulated loads	130,510	130,510	11,980	142,490	43,031	43,031	1,984	45,014
EFDC simulated export from Canyon Lake	NA			289,624	NA			56,545
Atmospheric Deposition	1,918			11,702	221			108
subtotal of external sources	132,428			443,816	43,252			101,667
Internal CL loading	13,549			NA	4,625			NA
Internal LE loading	NA			197,370	NA			33,160
Total	145,977			641,186	47,877			134,827

Table 5-10b. Total nutrient loads to Canyon Lake and Lake Elsinore for thee moderate scenario (all numbers in kg/yr)

Scenario II: Moderate Condition - Canyon Lake overflowed but Mystic Lake did not overflow (WY1994)

	Total Nitrogen				Total Phosphorus			
Nutrient Sources	Into Canyon Lake	From CL to LE	Local LE Watershed	Into Lake Elsinore	Into Canyon Lake	From CL to LE	Local LE Watershed	Into Lake Elsinore
Agriculture	4,152	4,152	224	4,375	1,363	284	30	314
Urban	3,992	3,992	398	4,390	894	186	76	262
CAFO	621	621	0	621	53	11	0	11
Open/Forest	985	985	349	1,334	314	65	100	165
Septics	1,155	1,155	358	1,513	75	16	21	37
subtotal of LSPC simulated loads	10,904	10,904	1,329	12,233	2,700	562	227	789
EFDC simulated export from Canyon Lake	NA			6,329	NA			0
Atmospheric Deposition	1,918			11,702	221			108
subtotal of external sources	12,822			30,264	2,921			897
Internal CL loading	13,549			NA	4,625			NA
Internal LE loading	NA			197,370	NA			33,160
Total	26,371			227,634	7,546			34,057

Table 5-10c. Total nutrient loads to Canyon Lake and Lake Elsinore for the dry scenario (all numbers in kg/yr)

Scenario III: Dry Condition - Neither Mystic Lake nor Canyon Lake overflowed (WY 2000)

	Total Nitrogen				Total Phosphorus			
Nutrient Sources	Into Canyon Lake	From CL to LE	Local LE Watershed	Into Lake Elsinore	Into Canyon Lake	From CL to LE	Local LE Watershed	Into Lake Elsinore
Agriculture	4,099	162	68	230	931	231	7	238
Urban	2,845	112	89	201	359	89	13	102
CAFO	543	21	0	21	29	7	0	7
Open/Forest	855	34	111	145	196	48	26	74
Septics	3,143	124	59	184	159	39	3	42
subtotal of LSPC simulated loads	11,485	453	327	781	1,674	414	49	463
EFDC simulated export from Canyon Lake	NA			0	NA			0
Atmospheric Deposition	1,918			11,702	221			108
supplemental water	248			59,532	NA			14,883
subtotal of external sources	13,651			72,015	1,895			15,454
Internal CL loading	13,549			NA	4,625			NA
Internal LE loading	NA			197,370	NA			33,160
Total	27,200			269,385	6,520			48,614

Figures 5-17 through 5-20 depict the relative contribution of nutrient sources for the three scenarios, a wet year as in 1998, a moderate year as in 1994, and a dry year as in 2000. As shown in Figure 5-17, in 1998, the nitrogen loads estimated by model simulation to enter Canyon Lake were principally from external sources: agriculture (32%), septic systems (22%), urban (13%), open space/forest (12%), CAFOs (10%), and internal sediment loading (9%). By contrast, in a moderate or a dry year, internal loading was the most significant source of nitrogen to Canyon Lake (over 50%). For a moderate year, other significant sources of nitrogen include agriculture (17%), urban (15%), atmospheric deposition (7%), open space/forest, and septic systems (4%). In a dry year, the other sources of nitrogen are agriculture (15%), septic systems (12%), urban (11%), and atmospheric deposition (7%).

As shown in Figure 5-18, phosphorus loads to Canyon Lake in a wet year (1998) came from agriculture (45%), open/forest (25%), internal loading (10%), urban areas (8%), CAFOs (6%) and septic systems (6%). Similar to nitrogen loads, internal loading was the most significant source of phosphorus in a moderate and dry year (61% and 72%, respectively). Other sources of phosphorus to Canyon Lake include agriculture (18%) and urban (12%) in a moderate year. In 2000, 14% of phosphorus came from agriculture, 6% from urban, 3% from atmospheric deposition, 3% from open space/forest, and 2% from septic systems.

As shown in Figure 5-19, in 1998, 46% of the nitrogen load into Lake Elsinore came from export from Canyon Lake. As explained previously, this load was determined using the EFDC model output, which was calibrated to the water column concentration at one sampling station in Canyon Lake. This may represent the flushing effect of Canyon Lake during wet years. Canyon Lake may have been flushed several times depending on the volume of water flowing through Canyon Lake; nutrients in the water column as well as in the sediments in Canyon Lake were washed down to Lake Elsinore. Internal loading was the second largest source of nitrogen (31%) to Lake Elsinore in 1998. Other sources of nitrogen to Lake Elsinore include agriculture (8%), septic systems (6%), urban (3%), open space/forest lands (3%), and CAFOs (2%). In a moderate year as in 1994, approximately 90% of the nitrogen load to Lake Elsinore came from internal loading. Other less significant sources include atmospheric deposition (5%), export from Canyon Lake (3%), agriculture (2%), and urban (2%). In a dry year (2000), 94% of nitrogen load came from internal loading and 6% from atmospheric deposition. The nitrogen load from recycled water discharges was included in Figure 5-19 to show that 22% of the nitrogen would have been from the reclaimed water had the 6050 AFY of recycled water been added to the lake in 2000. (As noted in Table 5-11, these discharges did not commence until 2002, and the discharge amount is less than 5000AF.)

A similar distribution pattern is observed for phosphorus loading to Lake Elsinore (Figure 5-20). In a wet year like 1998, 42% of the phosphorus loads to Lake Elsinore were transported from Canyon Lake, and 25% came from internal loading from Lake Elsinore sediments. Other sources of phosphorus include agriculture (16%), open space/forest land (10%), urban (3%), septic systems (2%), and CAFOs (2%). Once again, in moderate and dry years, the most significant source of phosphorus to Lake Elsinore is internal loading. Other sources of phosphorus in a moderate year include export from Canyon Lake (3%), agriculture (2%), and urban (2%). The phosphorus load from recycled water was included in Figure 5-20 to show that recycled water would have contributed 31% of the total phosphorus load to Lake Elsinore had it been discharged in 2000.

In all modeled scenarios, phosphorus loading from atmospheric deposition was not significant (generally less than 1% of the total load). Under moderate and dry conditions, atmospheric deposition makes up 7% of the total nitrogen load to Canyon Lake, and 5% of the total nitrogen load to Lake Elsinore.

The distinctly different distribution of nutrient loads to Lake Elsinore and Canyon Lake under wet and dry conditions seems to suggest that different load allocation schemes would maximize effective water quality improvements in both lakes. Under wet conditions, sources in the San Jacinto River watershed such as agriculture, septic systems and urban areas contribute significant amounts of nutrients to Canyon Lake based on the LSPC model simulations by Tetra Tech (2003). For Lake Elsinore, however, export of nutrients from Canyon Lake and internal loading from Lake Elsinore sediments are the dominant sources of nutrients. Further, under dry conditions (2000), lake sediments are the dominant source of nutrients for both Lake Elsinore and Canyon Lake. This phenomenon was independently confirmed by studies of sediment characterization and nutrient release rate determination by Anderson (2001), and Anderson and Oza (2003).

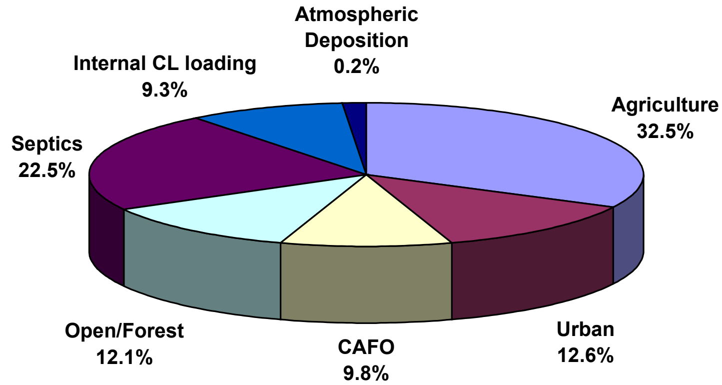
While separate load allocation schemes based on hydrologic condition would arguably be most appropriate, they would be difficult to implement. Implementation would require an accurate prediction of hydrological condition in any given year in order to decide which allocation scheme must be met. Furthermore, separate load allocation schemes would not take into account the cumulative nature of nutrient inputs under the variety of hydrologic conditions. As previously discussed, nutrient loads are accumulated in the lakes and have a prolonged effect on water quality that is not limited to any particular hydrologic condition. To address both these concerns, a TMDL approach based on 10-year running average is recommended (see Sections 6.0 and 7.0). Further, as will be discussed later, the TMDL, WLAs and LAs are based on the weighted average of nutrient loads from sources under each of the three hydrological scenarios, taking into consideration the relative frequency of the each scenario. Existing nutrient loads from the watershed sources based on weighted averages, are shown in Tabled 5-11. As discussed next, the weighted average loads will be allocated among the sources. The allowable loads for each source will then be compared to the existing, weighted average load for each source (Table 5-11) to determine the reductions that will be required to meet the recommended numeric targets.

Table 5-11. Total nitrogen and phosphorus loads to Canyon Lake and Lake Elsinore (weighted average of three hydrologic scenarios, all numbers are in kg/yr)

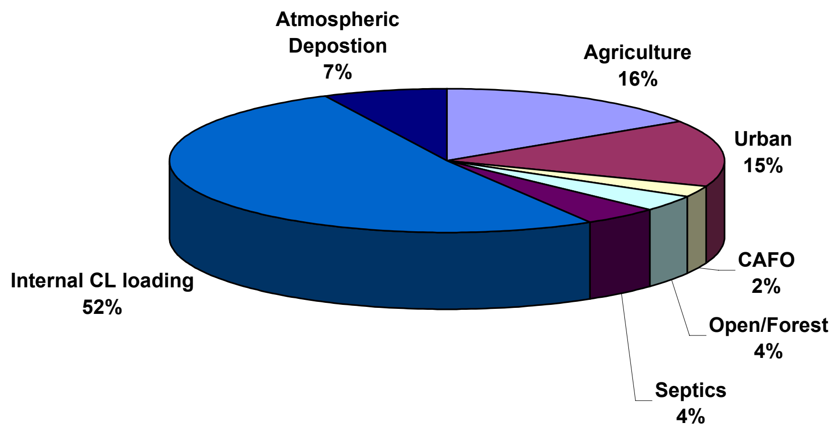
Weighted Average Nutrient Load Distribution

	Total Nitrogen				Total Phosphorus			
Nutrient Sources	Into Canyon Lake	From CL to LE	Local LE	Into Lake Elsinore	Into Canyon Lake	From CL to LE	Local LE	Into Lake Elsinore
Agriculture	11,057	9,364	371	9,735	4,413	3,670	60	3,730
Urban	5,794	4,619	606	5,225	1,142	736	124	861
CAFO	2,783	2,558	0	2,558	494	467	0	468
Open/Forest	3,586	3,233	567	3,800	2,144	1,978	178	2,157
Septics	7,071	5,773	1,058	6,831	518	441	69	511
subtotal of LSPC simulated loads	30,291	25,547	2,602	28,150	8,712	7,294	431	7,725
EFDC simulated export from Canyon Lake				48,935				9,047
Atmospheric Deposition	1,918			11,702	221			108
supplemental water	248			59,532	NA			14,883
subtotal of external sources	32,457			148,319	8,933	7,294	431	31,763
Internal CL loading	13,549			NA	4,625			NA
Internal LE loading	NA			197,370	NA			33,160
Total	46,006			345,689	13,558			64,923

Wet



Moderate



Dry

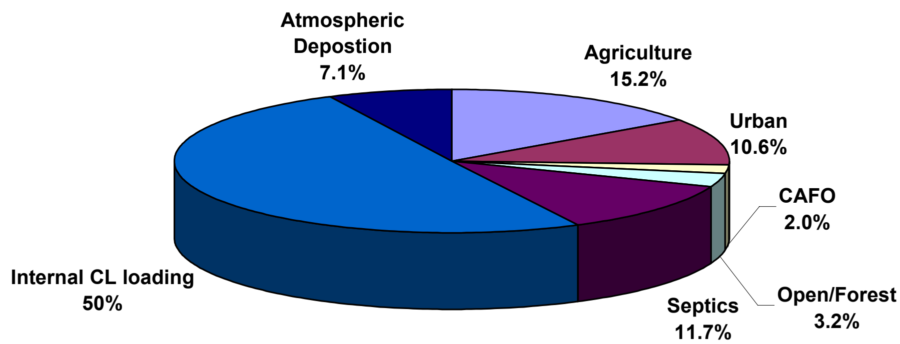


Figure 5-17. Total nitrogen load to Canyon Lake under three scenarios: wet year as in 1998 (top), moderate year as in 1994 (middle), and dry year as in 2000 (bottom) (see Tables 5-9a, 5-9b, 5-9c)

Wet

Moderate

Dry

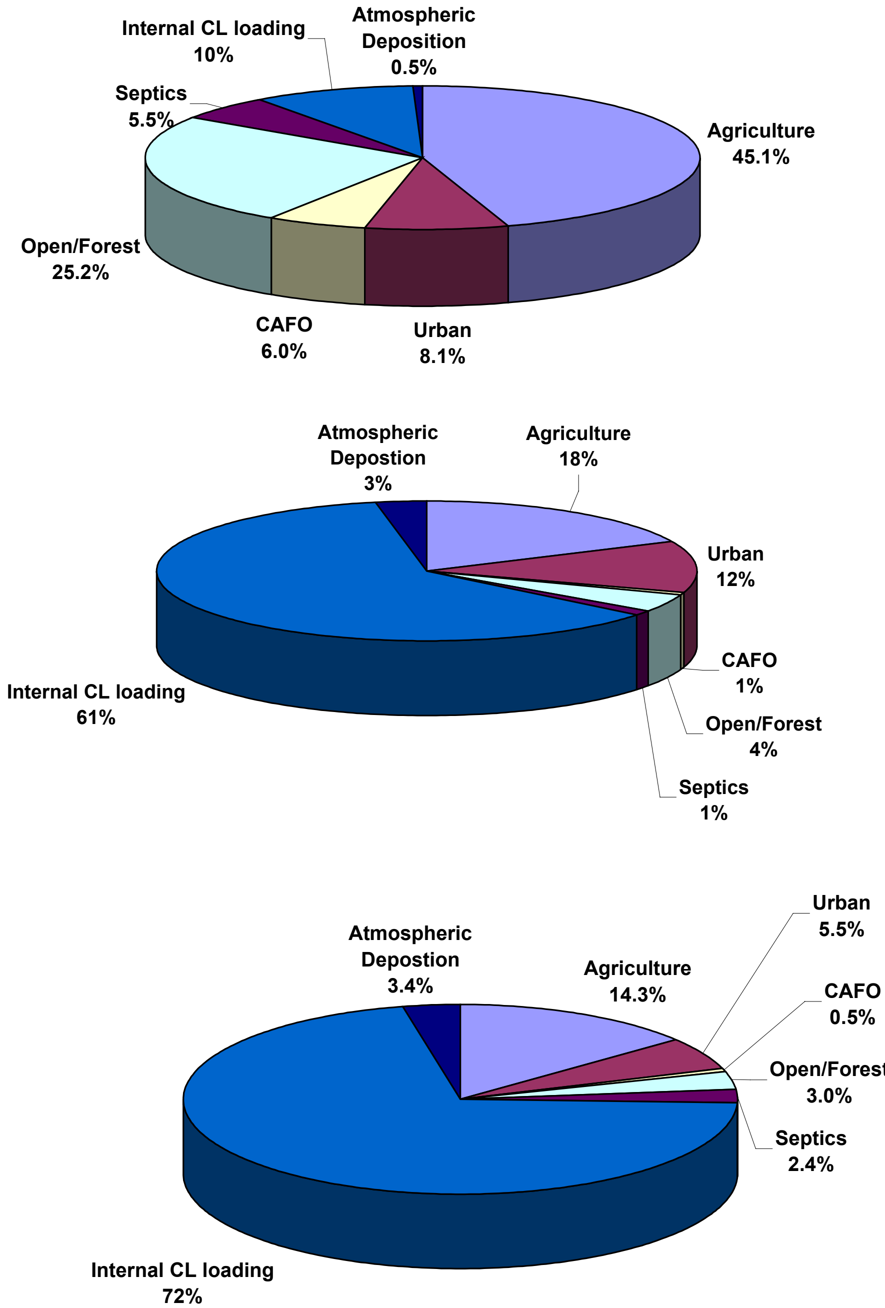


Figure 5-18. Total phosphorus load to Canyon Lake under three scenarios: wet year as in 1998 (top), moderate year as in 1994 (middle), and dry year as in 2000 (bottom) (see Tables 5-9a, 5-9b, 5-9c)

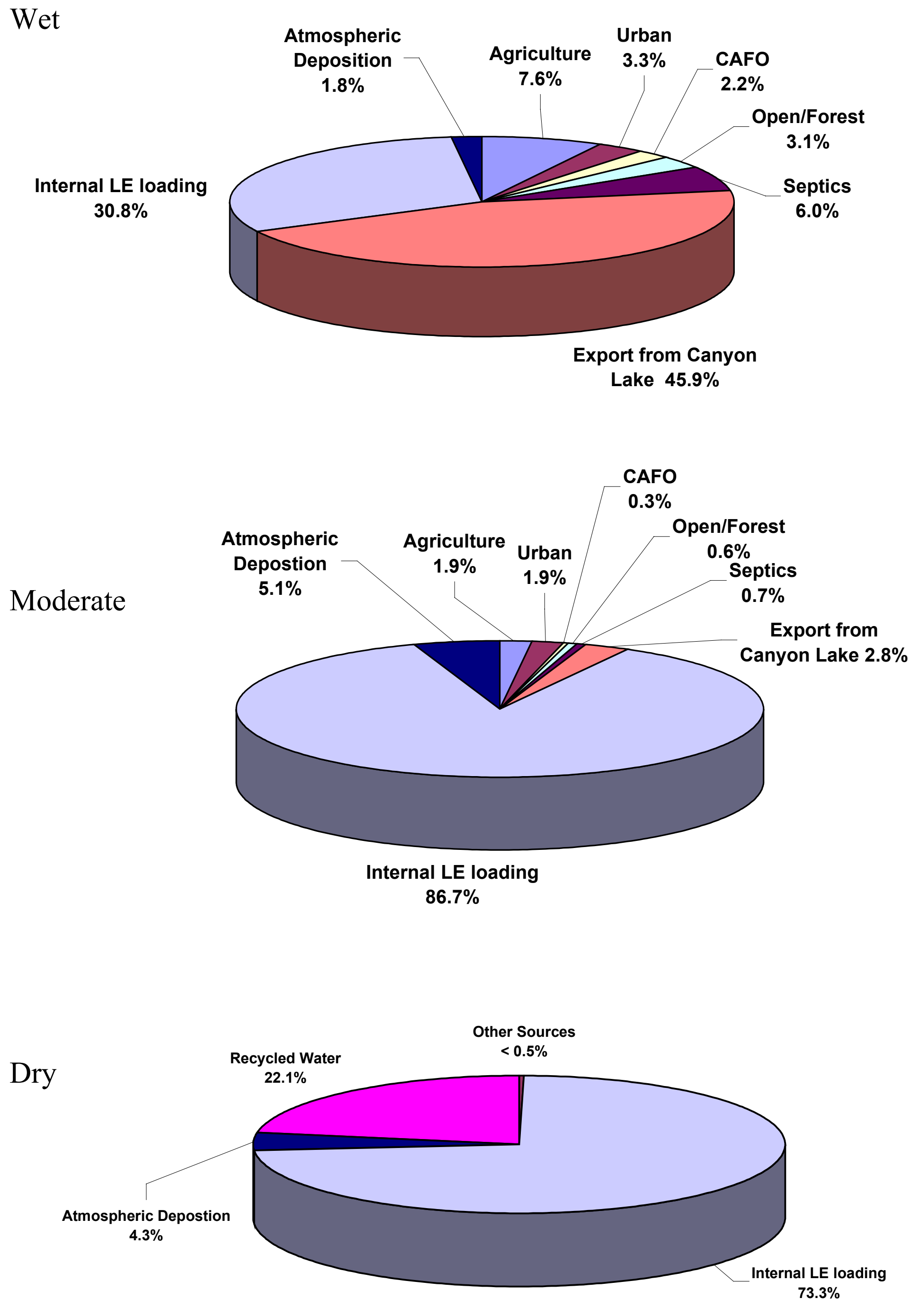
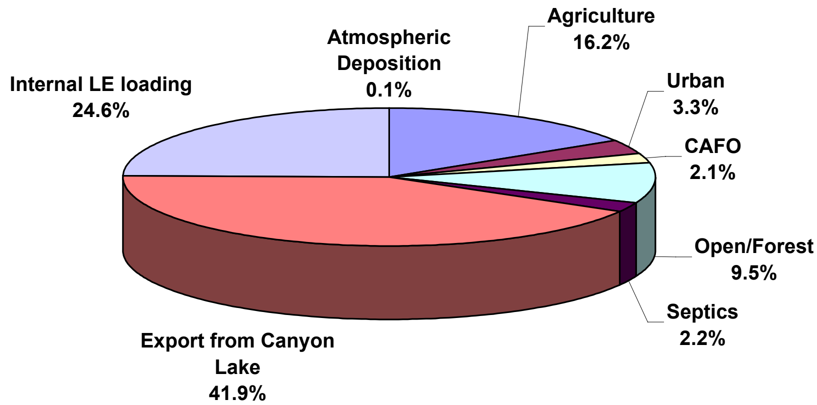
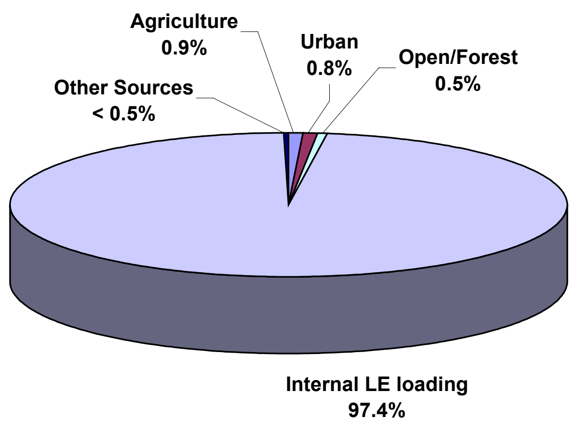


Figure 5-19. Total nitrogen load to Lake Elsinore under three scenarios: wet year as in 1998 (top), moderate year as in 1994 (middle), and dry year as in 2000 (bottom) (see Tables 5-9a, 5-9b, 5-9c)

Wet



Moderate



Dry

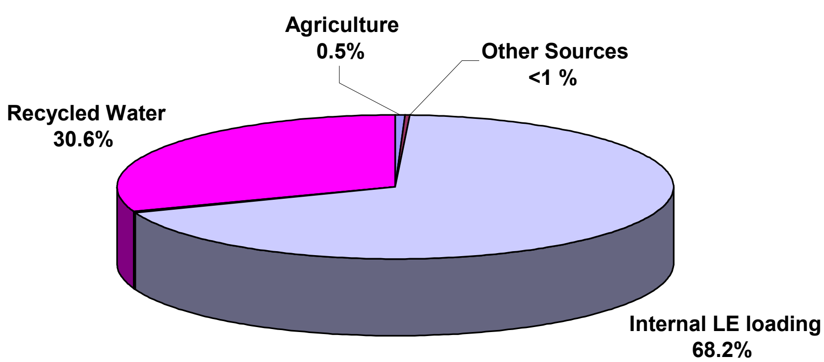


Figure 5-20. Total phosphorus load to Lake Elsinore under three scenarios: wet year as in 1998 (top), moderate year as in 1994 (middle), and dry year as in 2000 (bottom) (see Tables 5-9a, 5-9b, 5-9c)